Chapter 4
ANALYSIS AND EVALUATION OF MODEL RESULTS

ANALYTICAL PROCESS OVERVIEW

Both regional and subregional computer hydrologic simulations were used extensively by the South Florida Water Management District (District, SFWMD) to help develop the *Lower East Coast (LEC) Regional Water Supply Plan*. The South Florida Water Management Model version 3.7 (SFWMM) was used as the principal tool to evaluate overall regional performance, while subregional ground water models were used to simulate impacts at smaller scales, such as effects within service areas and impacts of individual wellfields. Data from SFWMM and subregional ground water model simulations were analyzed and interpreted to determine how to modify and improve the District's water management practices, the major features of the Central and Southern Florida Project for Flood Control and Other Purposes (C&SF Project), and local water management facilities to meet the future water needs of South Florida. First, present and future Base Case simulations of the regional SFWMM and the subregional ground water models were made to determine water requirements. From these model simulations it is possible to depict historic and future water distributions to all service areas, the frequency and severity of water shortages, and analysis of environmental goals. This informations allowed the regional capacity and future water needs of the LEC Planning Area to be evaluated. Second, the effects of the projects recommended in the C&SF Project Comprehensive Review Study (Restudy) that will be constructed by 2020 were determined. Major features of this project will dramatically affect water use and supply throughout the region. The analysis of the Restudy components includes a similar analysis of water distribution and water shortages and an analysis of how successfully environmental restoration goals are achieved by 2020.

The LEC planning process then considered other options, in terms of either local water supply development or regional water resource development projects that could be implemented to meet future agricultural, urban and environmental water supply needs by 2020. The planning goal of these efforts is that the local and regional projects combined provide sufficient water to meet the 1-in-10 year level of certainty criteria for urban and agricultural water users, achieve the proposed minimum water criteria level, and substantially achieve long-term environmental restoration goals of the region. The ability to meet these demands, as identified in various statutes and mandates (meeting minimum flows and levels, providing for public and agricultural water supply needs and achieving Everglades restoration), was evaluated for each model simulation using a comprehensive set of performance measures.

Data from local land use comprehensive plans, utilities, University of Florida Institute of Food and Agricultural Sciences (IFAS), and District permits were used to support these analyses. Conservative best professional judgement was used in circumstances where specific information was not available.

South Florida Water Management Model

The regional South Florida Water Management Model (SFWMM) was used to simulate the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland, and ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water pumping. This large scale (two mile by two mile grid size) regional model was developed specifically for the South Florida system, and is currently the best available tool that can simulate both the current and future operational complexities of the regional water control system and provide adequate technical information to make water management decisions (see **Chapter 2** and **Appendix E** for more information on the SFWMM). The Base Case simulations incorporated current or proposed water management control structures, operational rules, and water shortage policies. Daily hydrologic conditions were simulated using climate data for the 1965-1995 period of record, which includes droughts and wet periods.

Subregional Ground Water Models

Although the SFWMM is the principal tool used in the evaluation of the *LEC Regional Water Supply Plan*, five higher-resolution, subregional ground water flow models were developed as part of the planning process to evaluate potential benefits and impacts of specific options on local resources. Ground water models developed during this planning process include: (1) the North Palm Beach Ground Water Model; (2) the South Palm Beach Ground Water Model; (3) the Broward Ground Water Model; (4) the North Miami-Dade Ground Water Model; and (5) the South Miami-Dade Ground Water Model. These models use the United States Geological Survey (USGS) modular three-dimensional finite difference ground water flow model, commonly known as MODFLOW. More information concerning these models is provided in **Chapter 2** and each model is described in greater detail in **Appendix F**.

The ground water models were also used to estimate the 1-in-10 year level of certainty for public and agricultural water uses. The simulation period of each model was January 1987 to December 1990. Results are reported only for the last two years to allow the models to “warm up” for one year. The simulation period from January 1989 to December 1990 contains rainfall-deficient conditions that are approximately equivalent to a 1-in-10 year drought.

Other Models

Modeling was also used to analyze water availability and water demands in the Caloosahatchee Basin. These modeling efforts are described in the *Caloosahatchee Water Management Plan* (SFWMD, 2000d). Analytical tools used in this analysis included the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) Model, the Water Management Optimization Model, and the MIKE SHE model. The AFSIRS is a surface water budget model which was used to approximate surface water availability in each of the major surface water subbasins in order to quantify the demands that could not be satisfied by surface water. The Water Management Optimization Model was used to determine how to best store and release water as needed for water demands and environmental needs. The MIKE SHE model is an integrated surface water/ground water model used to identify potential impacts of water use on the environment and water resources.

RELATIONSHIP BETWEEN GOALS AND PLANNING CRITERIA

The model simulations were evaluated based on analysis of the planning criteria required by state statute (Section 373.036, F.S.):

- Provide for a 1-in-10 year level of certainty for users, without causing harm
- Protect water resources from significant harm
- Restore hydropatterns to water resources

The performance measures indicate the degree to which the water resource development projects and water supply options are likely to meet the goals and objectives of the *LEC Regional Water Supply Plan*. Performance measures are specific, selected hydrologic targets that are outputs of the Natural Systems Model (NSM), SFWMM, and subregional ground water models. Results based on key performance measures that best summarize the performance of the simulations are presented in later in this chapter.

PLANNING CRITERIA AND PERFORMANCE MEASURES

1-in-10 Year Level of Certainty

Each model requires a different approach to determine if a 1-in-10 year level of certainty can be met for urban and agricultural water users. In the Restudy, the 1-in-10 year level of certainty for water supply was determined based on a performance measure that considered the probability that water shortages would be declared during the 31-year period simulated by the SFWMM. An additional performance measure for 1-in-10 year level of certainty was developed for this analysis. The subregional ground water models simulate 1-in-10 year rainfall deficit drought conditions. Performance measures based on simulated ground water stages were used to determine how well local water demands were met without causing harm to the environment.

Meeting 1-in-10 Year Level of Certainty for Water Supply During the 31-Year Period of Record

One measure of the ability to meet water supply demands for the Lake Okeechobee Service Area (LOSA) and Lower East Coast Service Area (LECSA) is if water supply restrictions can be avoided during the 31-year period of record except during the most severe droughts. State law enables the District to impose water restrictions during droughts to conserve regional water resources. The SFWMM mimics this policy by imposing restrictions on consumptive users when regional water supplies are diminished. Water demands are cut back when low ground water stages occur in selected trigger cells (based on historical monitoring well locations) located along the lower east coast of Florida, low stages in Lake Okeechobee or Water Conservation Area (WCA) canals, or due to continuation of the restriction in the dry season. The SFWMM restricts water supplies in each LEC service area if LOSA is in Supply-Side Management for seven days consecutively during the dry season (October - May). LOSA is placed on Supply-Side Management restrictions (or cutbacks) when Lake Okeechobee levels are expected to be lower than 11 feet NGVD at the end of the dry season (May 31). The Supply-Side Management criteria conserves water in the lake to meet crucial events in the future and thereby reduce the risk of serious or significant harm.

Results from the SFWMM are displayed for LOSA and each LEC service area in a table format. The table displays the type, severity, and duration of cutbacks by water year (October - September). Types of cutbacks include Lake Okeechobee levels, low ground water levels along the coast, and dry season criteria. Water years are used since counting water demand cutbacks by calendar year would in some areas double count events that extend through the dry season. The graphic summarizing these SFWMM results is entitled *Frequency of Water Restrictions for the 1965-1995 Simulation Period* (see **Appendix D** for an example).

The target for LOSA and LECSA is to meet a 1-in-10 year level of certainty for water supply as determined by counting the number of water years when significant water supply cutbacks occur due to exceeding Supply-Side Management criteria on the lake. A significant water supply cutback event is an event when the total volume of water not supplied to LOSA exceeds 100,000 acre-feet. To meet the 1-in-10 year level of certainly criterion in LOSA and LECSA, significant water supply cutbacks should occur due to Lake Okeechobee stages in no more than three water years during the 31-year period of record.

For LECSA, additional information from the subregional ground water models is needed to assess local ground water conditions. The SFWMM's large cell size and emphasis on surface water hydrology limits its ability to simulate ground water levels and withdrawals along the coast near the model boundary. The ability of the SFWMM to distinguish between water stages at the trigger well and nearby withdrawal wells is limited because the trigger well and withdrawal wells can occur within the same model grid cell. More precise results can be achieved with the subregional ground water models.

Meeting the Level of Certainty for Water Supply During a 1-in-10 Year Drought Event

The second measure of the ability to meet water supply demands is to avoid water supply restrictions during a 1-in-10 year drought, or rainfall deficit, event. The ground water models approximate District water shortage policy by simulating restrictions on consumptive users. The ground water models simulate local ground water conditions more accurately than the SFWMM, due to the smaller grid cell size, stratification of the aquifer, and by virtue of being a ground water model.

In the subregional ground water models, the LECSA is divided into Water Restriction Areas to more accurately reflect how the District's water shortage policy may be implemented. Results from ground water models are displayed spatially for each service area and as a table showing locations of trigger cells and the severity and duration of cutbacks by cause: Lake Okeechobee levels, low ground water levels along the coast, or dry season criteria. Information on cutbacks due to Lake Okeechobee stages is imported from the SFWMM to the subregional ground water models.

Due to the size and complexity of the subregional ground water models, they simulate a shorter period of record that includes a 1-in-10 year rainfall deficit event. It begins June 1989 and ends May 1990 for North Palm Beach, LEC Service Area 1 (LECSA 1), and LEC Service Area 2 (LECSA 2). The rainfall drought for LEC Service Area 3 (LECSA 3) begins and ends one month earlier. Regional conditions are from the same historical period and are considered to be within the range of average regional flows from ground and surface water sources (see Appendix J for more information). To meet a 1-in-10 year level of certainty in LECSA, no water restrictions should occur during the 1-in-10 year drought event due to low ground water stages in selected trigger cells as simulated by the ground water models. The graphic summarizing these results is entitled *Frequency and Severity of Water Restrictions by Water Restriction Area* (see **Appendix D** for an example).

Saltwater Intrusion Analysis

Areas within the LEC Planning Area having the highest potential for saltwater intrusion were determined using the following criteria:

- Water restriction frequency and duration
- Ground water stages as indicated by water shortage trigger wells
- Net westward ground water flow along the saline water interface

The application of water restrictions was discussed above. The two remaining factors are discussed below.

Water Levels as Indicated by Water Shortage Trigger Wells

Information about ground water stages at trigger wells is obtained as an output from the subregional ground water models. Analysis of ground water stages along the coast are indicative of changes elsewhere in the LEC Planning Area. Water shortage triggers, or water levels at which phased restrictions will be declared under the District's water shortage program, can be used to curtail withdrawals by water use types. Such curtailment is imposed to avoid water levels declining to and below a level where serious and significant harm (i.e., saltwater intrusion) could potentially impact water resources (such as the Biscayne aquifer).

Saline Water Intrusion Criterion

The saline water intrusion criterion for the *LEC Regional Water Supply Plan* is defined as follows: water use withdrawals should not cause water flows towards the east in the Surficial Aquifer System to be less than the flows west near the saline water interface during a 12-month drought condition that occurs as frequently as once every 10 years. If ground water flow east towards the coast is less than the flow west, the saline interface has the potential to move. Ground water flows east were subtracted from the westward flows to calculate the net westward flow. Only positive flows (to the west) are shown in the performance measure graphic. The net flow is calculated for all layers of the models based on results of the subregional ground water models in the LEC service areas.

This protection criterion is established to protect the quality and sustainability of the Surficial Aquifer System, in the LEC Planning Area, and to avoid impacts to existing users. The subregional ground water models used in analyses for the *LEC Regional Water Supply Plan* are not configured for use as chemical transport models and therefore they cannot be used directly as indicators of saline water intrusion. Instead, staff assumed that net westward flow of water across the location of the interface is an indicator of potential intrusion. In general, proximity of a water use to the saline water interface necessitates a detailed evaluation prior to implementing an alternative or issuance of a consumptive use permit. Given the regional nature of the plan, this analysis method was used to screen for the potential of coastal wellfields to induce westerly flow of saline water over a large area. It is just one method to evaluate if the potential for salt water intrusion exists. Additional criteria or refinement of this methodology will be applied during the CUP process. An example of this performance measure is available in **Appendix D.**

Isolated Wetland Protection Criteria

Criteria have also been defined for isolated wetlands which lie outside of the Everglades Protection Area in the LEC and Lake Okeechobee service areas and are protected from harm due to water use permits up to 1-in-10 year droughts. The following criteria was applied to results from the subregional ground water models: ground water stage drawdowns induced by cumulative pumping withdrawals beneath wetlands should not exceed one foot at the edge of the wetland for more than one month during a 12-month drought condition that occurs as frequently as once every 10 years. For planning purposes, this criterion was applied to surficial aquifer drawdowns in areas that have been classified as wetlands according to the National Wetlands Inventory (NWI). The NWI cover was partially updated to reflect urban development changes near wellfields.

Because of variation in methodology for identifying and characterizing wetlands, as well as temporal changes that occur in wetland characterization resulting from environmental resource mitigation activities, maintaining a detailed regional geographic inventory of local wetlands conditions is difficult and beyond the scope of this plan. Instead, the best available geographic data was assimilated and processed to provide a reasonable representation of locations of wetlands. In practice, implementation of the *LEC Regional Water Supply Plan* will require an inventory of potentially affected wetlands for protection or mitigation. Further, the plan criteria here do not replicate the Consumptive Use Permit (CUP) Program criteria, which will undergo rulemaking as part of the implementation of the District's regional water supply plans. The *LEC Regional Water Supply Plan*'s criteria are used as a screening tool to alert future permittees of the need to evaluate wetlands in the vicinity of proposed withdrawals. More information regarding future rulemaking is included in Chapters 5 and 6.

Minimum Flows and Levels

Minimum Flows and Levels (MFLs) identify the point at which further withdrawals would cause significant harm to the water resources. The LEC Regional Water Supply Plan is statutorily required to achieve MFLs that have been established for priority surface water bodies and aquifers or to develop a recovery and prevention strategy for those water bodies that are expected to exceed the proposed criteria. In the LEC Planning Area, MFLs have been proposed for three priority water bodies: Lake Okeechobee, the Everglades, and the Biscayne aquifer. The criteria defined in the *Minimum Flows and Levels for Lake Okeechobee, the Everglades, and the Biscayne Aquifer Final Draft Report* dated February 29, 2000 (SFWMD, 2000e) are described below and were incorporated into the modeling targets for the *LEC Regional Water Supply Plan*. In addition, MFLs are scheduled to be established for the Caloosahatchee River. These criteria were addressed in the *Caloosahatchee Water Management Plan* (SFWMD, 2000d) and also incorporated into the *LEC Regional Water Supply Plan*.

The ability to meet the proposed MFL criteria was determined by examining flow rates, water depth, duration of low water conditions, and return frequencies in Lake Okeechobee, coastal canals, and at various locations in Everglades’ peat soil and marl soil environments. The ability to achieve MFLs was assessed using the SFWMM for the 31-year simulation period. The subregional models were not used for such analyses because of the relatively short time period (two years) evaluated in these models and because they do not simulate Lake Okeechobee, coastal canal stages which are part of the Biscayne aquifer criteria, or all of the Everglades MFL sites.

Meeting Proposed MFL Criteria for Lake Okeechobee

Significant harm criteria developed for Lake Okeechobee were based on the relationship between water levels in the lake and the ability to a) protect the coastal aquifer against saltwater intrusion, b) supply water to Everglades National Park, c) provide littoral zone habitat for fish and wildlife, and d) ensure navigational and recreational access. Consideration was also given to the lake's function as a storage area for supplying water to adjacent areas such as the Everglades Agricultural Area (EAA), the Seminole Indian Tribe, and the Caloosahatchee and St. Lucie basins.

Water Supply Planning MFL Criteria

The water level in the lake should not fall below 11 ft NGVD for more than 80 days duration, more often than once every six years, on average.

Meeting Proposed MFL Criteria for the Everglades

Technical relationships considered in the development of the MFLs for the Everglades included the effects of water levels on hydric soils, plant and wildlife communities, and frequency and severity of fires. Impacts associated with significant harm include increased peat oxidation, frequency of severe fires, soil subsidence, loss of aquatic refugia, loss of tree islands, and long-term changes in vegetation or wildlife. The proposed minimum water level criteria for the Everglades considered the two dominant soil types: peat soils and marl soils.

Peat Soils

Water levels within wetlands overlying organic peat soils within the WCAs, Rotenberger and Holey Land Wildlife Management Areas (WMAs), and Shark River Slough (Everglades National Park) shall not fall below ground surface for more than 30 days and shall not fall below 1.0 foot below ground for one day or more of that 30 day period, at specific return frequencies for different areas, as identified in **Appendix D**.

Marl Soils

Water levels within marl-forming wetlands that are located east and west of Shark River Slough, the Rocky Glades, and Taylor Slough within Everglades National Park, shall not fall below ground surface for more than 90 days and shall not fall below 1.5 foot below ground for one day or more of that 90 day period at specific return frequencies for different areas, as identified in **Appendix D**.

Meeting Proposed MFL Criteria for the Biscayne Aquifer

Technical relationships considered for the Biscayne aquifer included analysis of relationships among ground water levels, canal water levels, and saltwater intrusion. Harm occurs when the saltwater interface moves further inland than has occurred historically due to seasonal water level fluctuations, up to and including a 1-in-10 year drought.

Significant harm occurs when saline ground water moves inland to an extent that it limits the ability of users to obtain fresh ground water in the amounts specified in their permits and will require several years for the freshwater source to recover. The proposed criteria do not address the ground water base flows to Biscayne Bay or Florida Bay. Data is being developed to define MFLs for these water bodies in 2003.

Minimum Water Level

The term minimum water level for the Biscayne aquifer refers to levels associated with movement of the saltwater interface landward to the extent that ground water quality at the withdrawal point is insufficient to serve as a water supply source for a period of several years before recovering.

For evaluation of model simulations, operational criteria are applied to the coastal canals that receive regional water. **Table 4** provides the canal stage criteria. To meet the operational criteria, the canal stage cannot fall below the criteria for more than 180 days, and the average annual stage must be sufficient to recover after a drought or discharge event.

Table 4. Minimum Canal Operation Levels of Coastal Canals.

Canal/Structure	Minimum Canal Operation Levels to Protect Against MFL Violations (NGVD)
C-51/S-155	7.80
C-16/S-41	7.80
C-51/S-40	7.80
Hillsboro/G-56	6.75
C-14/S-37B	6.50
C-13/S-36	4.00
North New River/G-54	3.50
C-9/S-29	2.00
C-6/S-26	2.00
C-4/S-25B	2.20
C-2/S-22	2.20

Meeting Proposed MFL Criteria for Caloosahatchee Estuary

The proposed Caloosahatchee River MFL criteria is based on maintaining salinity levels in the Caloosahatchee Estuary that would avoid significantly harmful salinity levels in the estuary. Research data were used to relate flow rates to salinity distributions along the Caloosahatchee River and to correlate biologic community responses to varying salinity distributions. These relationships were established for submerged aquatic vegetation, fish, and invertebrates with major emphasis on the salinity requirements of the freshwater grass *Vallisneria*. It was determined that the distribution and abundance of *Vallisneria* at a location 30 kilometers upstream of Shell Point is the best biological indicator addressing low flow needs for the restoration of the Caloosahatchee Estuary. The magnitude of die off that requires two years to recover from and the resulting impact to fisheries resulting from the loss of *Vallisneria* habitat was considered to be significantly harmful and formed the basis of the proposed MFL criteria.

Minimum Water Level

Low flows, when sustained, produce salinities which result in die off of tape grasses to less than 20 shoots per square meter measured at a monitor station located 30 kilometers upstream of Shell Point during the months of February through April. Significant harm to the Caloosahatchee Estuary is considered to occur when freshwater grasses die back due to high salinity from low freshwater inflows for three years in a row. Harm to the Caloosahatchee Estuary, the area in the C-43 Canal between the 28 and 30 kilometer markers, is considered to occur when freshwater grasses die back due to high salinity from low freshwater inflows, for two consecutive years. The freshwater inflow associated with preventing harm or significant harm is an average of 300 cubic feet per second (cfs) per day at the S-79 Structure during the spring.

Environmental Resource Management Performance Indicators

Restoration Criteria from the Restudy

A number of resource protection criteria and performance measures relate to hydropattern restoration of wetland systems and mimic the performance targets and evaluation criteria utilized in development of the Restudy. The recommendations made within the Restudy will be refined and implemented in the Comprehensive Everglades Restoration Plan (CERP) currently being developed. District staff reviewed the Restudy natural area performance measures and indicators and incorporated them or revised versions into the *LEC Regional Water Supply Plan* as appropriate. Review of performance criteria showed that the model simulation for the LEC 2020 with Restudy features completed by 2020 did not match the performance of model simulation for 2050 with CERP (alternative D13R) because not all restoration components will be in place by 2020 (e.g., Lakebelt projects are only about 50 percent complete by 2020). It was also recognized that the D13R simulation did not meet every target in 2050, hence the 2020 LEC Regional Water Supply Plan will not necessarily meet all of the performance measure targets identified in the CERP. Performance measures used in the *LEC Regional Water Supply Plan* to evaluate the success of restoration efforts were developed to evaluate the potential for the following:

- Meet minimum flows and levels criteria
- Protection and accretion of peat and marl soils
- Protection of tree island communities
- Reestablishment of inundation patterns that will maintain Everglades sawgrass or ridge and slough marsh communities

In many areas, water conditions that were predicted to occur historically, based on results of the Natural Systems Model (NSM), were considered to be appropriate targets. For WCA-1 and WCA-3A, other targets were developed by the Restudy evaluation process that are more appropriate than NSM-like targets. Fourteen hydrologic subregions, called indictor regions were identified within the Everglades as shown in **Figure D-3** in **Appendix D**. Each Indictor Region is a group of model grid cells with similar vegetation and soil type. Performance of the model simulation was evaluated by considering the following performance measures, which are further described in **Appendix D**:

- Meet minimum flows and levels criteria for selected indictor regions
- Meeting NSM-defined patterns of surface water flooding inundation/duration where appropriate
- Evaluation of the number and duration of extreme high and low water events
- Interannual depth variation
- Temporal variation in mean weekly stage

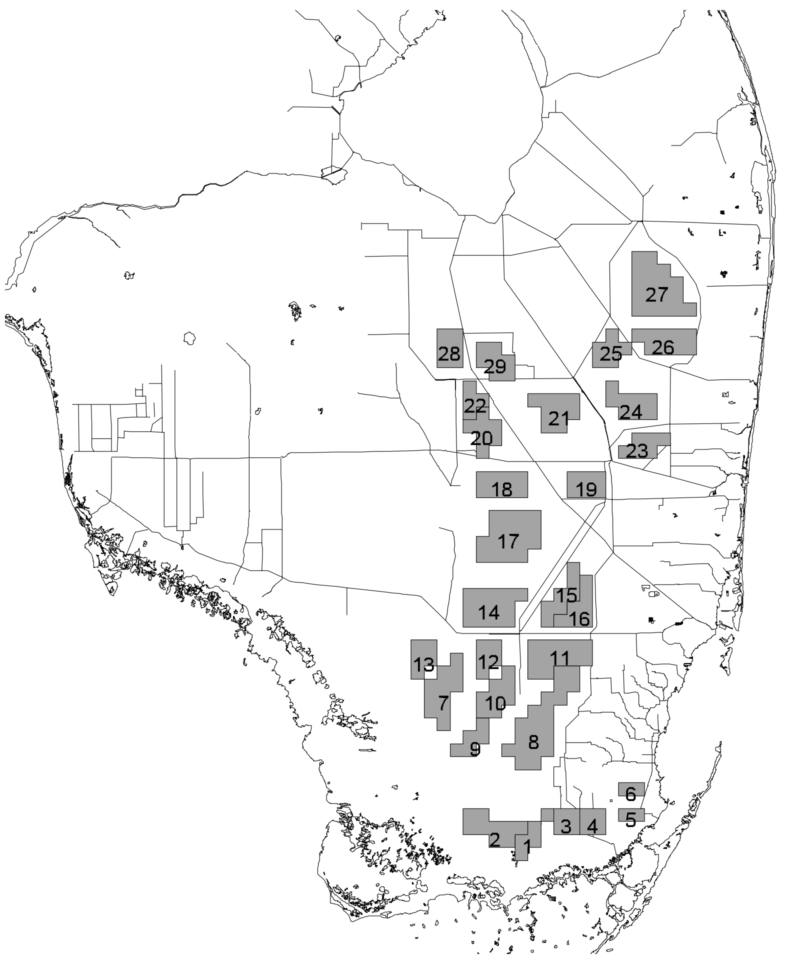

Figure 25. Locations of Indicator Regions Within the Everglades Evaluated by the SFWMM for the LECRWSP.

Extreme High and Low Water Criteria

The following performance measures were initially developed by the Southern Everglades Restoration Alliance Natural Systems Team. These performance measures were used to evaluate SFWMM output and identify those areas of the Everglades that may suffer from either extreme high water or extreme low water events that impact the structure and function of existing wetland communities. These same performance measures were also used to develop the recommendations to restore the Everglades as outlined in the Restudy (USACE, 1999). In implementing the plan, it will be necessary to recognize the fact that these performance measures, which are intended for comparison among model runs, are not likely to translate directly into management criteria. Instead, further work will be needed to develop the information base from which to establish actual high and low water levels targets for management purposes.

Low Water Criterion: For extreme low water events, a criterion of 1.0 foot below ground surface was used for all indicator regions in the northern Everglades where peat-forming wetlands occur. A criterion of 1.5 feet below ground surface was applied to marl-forming soils located within the southern Everglades. These criteria are similar to the MFL water depth criteria proposed for the Everglades (SFWMD, 2000e).

High Water Criterion: For extreme high water events, a criterion of 2.5 feet above the ground surface was used in the northern Everglades (WCA-1, WCA-2, and WCA-3, except for northeastern WCA-3A [Indicator Region 21]). These regions are part of the historic Everglades predrainage ridge and slough landscape (McVoy *et al.* in review), and include a variety of tree island types ranging from low stature peat islands that rise less than 1.0 foot above marsh ground elevation to tropical hardwood hammocks that exceed marsh ground elevation by more than 4.0 feet at their summits. The 2.5 feet criterion was based on several sources of information: 1) best professional judgement derived from federal and state agency scientists who have conducted research in the WCAs; 2) analysis of data collected from recent (1994 - 1995) high water events in WCA-3A (Guerra, 1998); and 3) recent tree island and slough water level information collected from WCA-3A and WCA-3B by the Florida Fish and Wildlife Conservation Commission (FFWCC) (Heisler and Towles, YEAR). For Indicator Region 21 in northeastern WCA-3A, a lower water depth criterion of 2.0 feet was used, based on the rationale that this area of the Everglades was originally part of the remnant sawgrass plains and overall depth targets should be lower than for the ridge and sough landscape.

Based on the recommendations of FFWCC staff, a high water criterion of 1.5 feet was used for the Rotenberger WMA, based on observations that tree islands in Rotenberger WMA (Indicator Region 28) have reduced elevations as a result of peat loss from wildfires. For the Holey Land WMA (Indicator Region 29), a criterion of 1.5 feet was initially set, based on FFWCC observations that tree island wildlife refuges in the Holey Land WMA are eliminated once water depths exceed 1.5 feet (Sasse, YEAR); this criterion was later revised to 1.75 feet following further discussion with the FFWCC staff. As a result, a value of 1.5 feet appears in SFWMM output tables for the Holey Land WMA, although District staff actually used 1.75 feet as a minimum target for interpreting model output.

Interim Management Targets for Other Areas

For the St. Lucie River, the low flow, high flow, and estuary protection flow rates as defined by ongoing research and management studies, were used as performance measures. For Lake Worth Lagoon, only a high flow criterion has been defined. The performance measures for Biscayne Bay are composed of mean annual wet and dry season surface flows from various tributary canals. For the purposes of this study, the performance target for Biscayne Bay is that future flows delivered to the estuary should not be more than 10 percent below the flows provided in the 1995 Base Case. For western Florida Bay and Whitewater Bay, performance is based on surface flow at key gages and total flows delivered to the estuaries across selected transects located in central Shark River Slough. Flow targets are based on the ability to sustain the aquatic resources in the bays. These provisional criteria are subject to change as additional studies are completed and the District completes the actions needed to define MFLs technical criteria and implement associated rules that affect these estuaries.

Additional Performance Indicators

Water Supply Performance Indicators

A number of additional performance measures are routinely evaluated to determine the ability of the regional water supply system to provide water to individual utilities. These measures are used to identify specific problem areas that may occur and possible causes and are used as a basis to develop solutions. Measures used include the following (see **Appendix D** for more information):

- Daily hydrographs for each trigger cell in water restriction areas
- Monthly volumes of simulated water supply cutbacks for restriction areas
- Percentage of annual demand not met, by use type, for restriction areas
- Frequency and severity of water supply restrictions

Hydrologic Performance Indicators

A number of additional measures were used in the evaluation that did not have specific targets, but were used to provide an overall indication of the relative behavior of each water supply alternative. Measures used include the following (see **Appendix D** for more information):

- Weekly stage hydrographs and stage-duration curves for selected indictor regions
- Normalized stage duration curves and hydrographs for selected indictor regions
- Hydroperiod distributions and hydroperiod matches

- Ground water flows, ground water heads, and overland flows

MODEL SIMULATIONS

Overview of Model Simulations

In the SFWMM and subregional ground water models, Base Case model simulations were conducted using both the 1995 estimated Public Water Supply demand (1995 Base Case) and the 2020 projected demand (2020 Base Case). The future Base Case assumed that a) water withdrawals for Public Water Supply reflect LEC utilities' preferred sources, b) future water users would withdraw water in the quantities indicated by public water suppliers, and c) existing agricultural and irrigation water users would use the same sources for both their current and future demands, unless information was made available indicating a change. The existing and projected uses of reclaimed water and Aquifer Storage and Recovery (ASR) systems (where information was available) were incorporated into the simulations.

In addition, the future Base Case assumes that other currently ongoing or proposed construction and planning efforts have been completed, including the Everglades Construction, Modified Water Deliveries to Everglades National Park, and the C-111 basin projects. Base Case simulations represent the no action approach to water resource and supply development and are not necessarily a likely scenario. Public water supplies for the projected population were withdrawn from existing facilities and/or facilities proposed by public water suppliers.

For the LEC 2020 SFWMM and subregional ground water model simulations that include Restudy components, it is anticipated that components of the Restudy will be substantially completed by 2020, with one notable exception: the Central and North Lakebelt storage areas. This project is expected to be only 50 percent complete by 2020.

Additional simulations were also made to determine the cumulative effects of water supply withdrawals by utilities. These are referred to as LEC-1A. For these simulations, public water supplies and supplemental irrigation uses for golf courses, nurseries, agricultural crops, and landscaping were eliminated from the subregional ground water model simulations. In the SFWMM, only Public Water Supply withdrawals were eliminated from the simulations. ASR facilities associated with the Restudy remained active.

SFWMM simulations were also made to determine incremental benefits of proposed operational and structural changes over time, to simulate conditions that may exist in 2005, 2010, and 2015, as features of the Restudy, the *LEC Regional Water Supply Plan,* and other activities are completed. An additional incremental modeling scenario, the 2005 SSM Scenario was also completed. The 2005 SSM Scenario was exactly the same as the 2005 incremental simulation except that in the 2005 SSM Scenario Lake Okeechobee stages at which supply-side management restrictions are triggered (indicated by the supply-side management line) were lowered by 0.5 feet from the beginning of October through the end of May. The Lake Okeechobee target for May 31 was also reduced from 11.0 to 10.5 ft NGVD in the 2005 SSM Scenario.

Even though both types of models, the SFWMM and the subregional ground water model, simulate the LEC service areas, and its associated Public Water Supply withdrawals, comparison of model results is not appropriate due to the difference in how features are simulated. Each model should be used to evaluate areas it is best suited. The SFWMM, with its ability to simulate overland flow in wetlands, Lake Okeechobee, and the coastal canals, and its long simulated period of record, is best suited to analyze regional trends in performance of those features. The ground water models with their small cells and stratification of the aquifer are adept at simulating small-scale features such as changes in wellfield locations, effects of ASR withdrawals, and ground water stages along the saline interface. The SFWMM and its large cells tend to lump and these features and limit its sensitivity to minute changes in assumptions.

Both types of models, the regional SFWMM and subregional ground water models, initially simulated five simulations: the 1995 Base Case, the 2020 Base Case, the 2020 with Restudy features, the LEC-1, and LEC-1A (no Public Water Supply). Acronyms for these simulations are provided in **Table 5**. The acronyms are used on the performance measure graphics compiled in **Appendix H**.

Table 5. Acronyms for SFWMM and Subregional Ground Water Model Base Case and Alternatives Simulations.

SFWMM Simulation	SFWMM Simulation Acronym	GW Model Simulation Acronym
1995 Base Case	95BSR	95Base
2020 Base Case	20BSR	20Base
2020 with Restudy	2020WR	20wres
LEC-1	LEC-1	LEC-1
LEC-1A	LEC-1A	LEC-1A

Assumptions for Base Cases and Alternatives

The regional and subregional models simulate hydrology of South Florida on a daily basis including major components of the hydrologic cycle: rainfall, evapotranspiration, infiltration, ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water withdrawals. The SFWMM uses the climatic conditions from the 1965 - 1995 period, which includes both droughts and wet periods, while the subregional ground water models simulate the dry period from January 1988 to December 1990. The 1995 Base Case provides an understanding of the how the 1995 water management system with 1995 land use and demands responds to historic (1965 - 1995) climatic conditions. The 2020 Base Case provides information of how the system would respond to anticipated future operations and demands under the same historic climatic conditions with currently authorized restoration projects implemented, but without Restudy features. Comparison of the 1995 and 2020 base cases shows system performance with increased demands and inclusion of new projects and operating criteria. The LEC 2020 with Restudy simulations provide information on how the system performs with the implementation of the Restudy projects that would be completed by 2020 along with 2020 demands and operating criteria. The LEC-1 provides information on how additional changes to model assumptions may alter hydrologic performance.

The LEC-1A simulation was undertaken to understand the impact that permitted consumptive uses might have on the regional system. Using the subregional ground water models, effects on wetlands can be evaluated by comparing ground water stages in the LEC-1 simulation to the LEC-1A simulation. The manner in which the SFWMM and subregional ground water models simulate this varies. The SFWMM does not include public water withdrawals in Palm Beach, Broward, Miami-Dade, and Monroe counties, but includes agricultural and landscape irrigation demands. The ground water models more closely mimic the permit review process by eliminating all consumptive uses (public water demands, agriculture, and landscape irrigation) within the models' boundaries from this simulation. In both simulations, ASR systems recommended in the Restudy operate as designed.

Primary Differences Between Base Cases and Alternatives

The major differences between the different types of model simulations are 1) changes in public water supply demands and locations of withdrawals, 2) inclusion of future projects and components, 3) modifications to Lake Okeechobee and WCA operation schedules, and 4) changes in the land use between 1995 and 2020 and the resulting effect on agriculture and landscape irrigation demands. **Table 6** provides a summary of the 1995 and 2020 base cases, the LEC 2020 with Restudy, and LEC-1 simulations.

Public Water Supply Demands

The simulations used two demand, or allocation, sets for public water supply in the LEC Planning Area: 1995 and 2020. The 1995 demands are estimated average annual demands for that year (286,429 MGY). The 2020 demands (43,411 MGY) are a projection of future demands provided by public water suppliers in January 1999. **Appendix B** contains a detailed discussion of estimated and projected public water supply demands. These projected 2020 average annual demands are used in the four 2020 simulations (2020 Base Case, 2020 with Restudy, LEC-1, and LEC-1 Revised). Most utilities continued their current per capita rate, while some anticipate a lower per capita coupled with higher population projections or vice versa.

The District also developed 2020 public water supply projections in the *Districtwide Water Supply Assessment* (*DWSA*) (SFWMD, 1998c). However, the average public water supply per capita rate for the LECSAs remains fairly constant for the utility (176 gpcd) and District projections (179 gpcd). The *DWSA* projected total demands in the

Table 6. Comparison of Assumptions the 1995 and 2020 Base Cases, 2020 with Restudy, and LEC-1 Simulations.

Feature	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Land Use for Urban and Agricultural Areas	Best available information for 1995 Condition	Projections based on county comprehensive plans and EAA; adjusted to reflect construction of STAs	Projections based on county comprehensive plans; adjusted to reflect construction of STAs and reservoirs as per Restudy	Projections based on county comprehensive plans; adjusted to reflect construction of STAs and reservoirs as per Restudy
Vegetation Cover for Natural Areas	Best available information; generally reflect conditions between 1990-1995	Best available information; generally reflect conditions between 1990-1995.	Best available information; generally reflect conditions between 1990-1995.	Best available information; generally reflect conditions between 1990-1995
LOSA/EAA Mean Annual Supplemental Irrigation Demands	170,000/372,000 ac-ft	191,000/335,000 ac-ft	239,000/327,000 ac-ft	227,000/328,000 ac-ft
Lake Okeechobee Regulation Schedule	Run 25 Schedule	Water Supply and Environmental (WSE) Schedule	Modified Run 25 Schedule	Modified WSE Schedule
Lake Okeechobee Supply-Side Management for LOSA	Yes	Yes	Yes	Yes
Caloosahatchee River Basin Demands (including municipal demands)	Demands Based on Historical Records	25 percent increase over 1995 average annual demands	25 percent increase over 1995 average annual demands	25 percent increase over 1995 average annual demands
Caloosahatchee Basin Backpumping	N/A	N/A	As per Restudy	Reduced to zero as per Caloosahatchee Water Management Plan
St. Lucie Demands	Based on Historical Records	Same as 1995	Same as 1995	Same as 1995
St. Lucie (C-44) Reservoir	N/A	N/A	As per Restudy	Modified as per Indian River Lagoon Feasibility Study
Seminole-Brighton Tribe Demands	28,500 ac-ft annual average; maximum 44,0000 ac-ft/yr	28,500 ac-ft annual average; maximum 44,0000 ac-ft/yr	52,000 ac-ft per year	28,500 ac-ft annual average; maximum 44,0000 ac-ft/yr
STAs Associated with the EAA	No	Yes	Yes	Yes
EAA Runoff Reduction and Make-Up Water BMP	No runoff reduction or make-up water delivered	No runoff reduction or make-up water delivered	20 percent EAA runoff reduction and make-up water delivered	No runoff reduction or make-up water delivered
Make-Up Water Associated with BMPs from LOK	No	No	No	No
WCA-1 Schedule	C&SF Interim Regulation Schedule	C&SF Interim Regulation Schedule	C&SF Interim Regulation Schedule	C&SF Interim Regulation Schedule
WCA-2 and WCA-3 Schedules	Current regulation schedule	Rain driven operations and Modified Water Deliveries Project	Rain driven operations	Rain driven operations
Everglades National Park Operations	Experimental Rainfall Delivery Plan via S-12s and S-333	As per Modified Water Deliveries Project	As per Restudy	As per Restudy
LECSA Population for Utilities	4,755,776 persons	6,951,998 persons as per LEC utility survey	6,951,998 persons as per LEC utility survey	6,951,998 persons, as per LEC utility survey
LECSA public water supply Demands on Surficial Aquifer System and Surface Water	Actual 1995 demands: 286,429 mgy (784.1 mgd)	Projected demands based on LEC utility survey: 443,411 mgy (1,214.8 mgd)	Projected demands based on LEC utility survey: 443, 411 mgy (1,214.8 mgd)	Projected demands based on LEC utility survey: 443,411 mgy (1,214.8 mgd)

Table 6. Comparison of Assumptions the 1995 and 2020 Base Cases, 2020 with Restudy, and LEC-1 Simulations.**(Continued)**

Feature	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
LECSA public water supply Wellfield Distribution	Actual 1995 locations	Utility preferred wellfield locations, as per LEC utility survey	As per Restudy	Modifications to eleven utilities preferred wellfield locations (LEC utility survey)
LECSA Water Shortage Policy	Yes	Yes	Yes	Yes
LEC Irrigation Demands on Surficial Aquifer System	Based on land use and climatic variation	Based on projected 2020 land use and climatic variation	Based on projected 2020 land use and climatic variation	Based on projected 2020 land use and climatic variation
Operational Adjustments to Meet MFL for Biscayne Aquifer	No	Canal operation criteria (in NGVD): C-51@ S-155 - 7.80 C-15@ S-40 - 7.80 C-16@ S-41 - 7.80 C-6 @ S-26 - 2.00 C-4 @ S-25B - 2.20 C-2 @ S-22 - 2.20	Canal operation criteria (in NGVD): C-51 @ S-155 - 7.75 C-16 @ S-40 - 7.75 C-15 @ S-41 - 7.75 C-6 @ S-26 - 2.50 C-4 @ S-25B - 2.50 C-2 @ S-22 - 2.50	Canal operation criteria (in NGVD): C-51 @ S-155 - 7.80 C-16 @ S-40 - 7.80 C-15 @ S-41 - 7.80 C-6 @ S-26 - 2.00 C-4@ S-25B - 2.20 C-2 @ S-22 - 2.20
L-8 Basin Project[a]	No	Yes, as per Interim Plan	Yes, as per Restudy	Yes, as per Restudy
Northern Broward County Secondary Canal Network[a]	No	Yes, as per Interim Plan	Yes, as per Restudy	Yes, as per Restudy
Miami-Dade Utility ASR[a]	No	150 mgd	150 mgd	75 mgd
Miami-Dade Reuse[a]	No	No	100 mgd at West Facility	50 mgd at West Facility

a. LEC Interim Plan Project

LEC Planning Area to be 389,440 MGY. The utility projections anticipate a 14 percent higher demand in 2020 than the estimates in the *DWSA*. The two projections are considered low and high projections that represent the range of possible future projections. Conservation of water may increase in the future as a greater percentage of houses use low flow fixtures, have smaller yards, or depend on reuse for irrigation, thus the lower projection may prove accurate. On the other hand, the population may grow at the rates the utilities anticipate and the higher demand projection may be reached. Using the higher demand in the *LEC Regional Water Supply Plan* is a more conservative approach. The water resource development projects are needed immediately to meet environmental demands regardless if future populations are less than projected. Regardless of the projection assumed for analysis in the *LEC Regional Water Supply Plan*, the population and demand projections will be reassessed during the Consumptive Use Permitting (CUP) process.

The physical location of public water withdrawals also varies between the 1995 and 2020 model simulations. In the 1995 Base Case, withdrawals are similar to historic conditions in 1995, i.e., only wells existing in 1995 and the corresponding wellfield distribution were included (**Figures 26**, **27**, and **28)**. In the future 2020 model simulations, locations of withdrawals include new wells built since 1995 and proposed locations provided by the public water suppliers to the Planning Department in January 1999

(**Figures 29**, **30**, and **31)**. The locations provided by the utilities are composed of their initial or preferred location for future withdrawal sites and the resulting distribution among the wellfields. To view how the SFWMM simulates these demands at the utilities preferred locations, refer to the Spatial Distribution of Public Water Supply Demands section for each of the bases in **Appendix B**. Some utilities proposed many new wells to meet future demands while others do not foresee constructing new wells by 2020.

The physical location of public water withdrawals also varies between the LEC 2020 with Restudy and the LEC-1 model simulations. In the LEC 2020 with Restudy, withdrawal locations are similar to those used in the Restudy's Alt D13R simulation (**Figures 32**, **33**, and **34)**. The Restudy relied upon the SFWMM and its four square mile grid to simulate LEC urbanized areas. The primary method to alleviate low ground water levels along the coast was to move public water supply demands inland. The large grid does not enable refinement of well distributions or locations that is possible with the subregional ground water models. In the LEC-1simulations, the majority of withdrawal locations are the same as in the 2020 Base Case. Eleven utilities had at least a portion, if not all, of their withdrawals relocated to existing wellfield locations further inland (**Figures 35**, **36**, and **37)** to reduce the threat of saltwater intrusion and/or reduce the frequency water supply restrictions. These locations are assumed only for modeling and planning purposes and are not meant to infer permitability.

Agricultural Water Supply Demands

In the SFWMM, the 1995 demand level represents estimated agricultural water demands for acreage that was permitted by the District through the end of 1995. For irrigation uses, demands for permitted acreage were calculated based on the crop type and simulated rainfall event. The 2020 demand level is based on estimated 2020 agricultural acreage, which is based on local county comprehensive plans. All irrigation demands were calculated using the modified Blaney-Criddle method for each rainfall condition. A detailed discussion of this method can be found in the District's *Management of Water Use Permitting Information Manual, Volume III* (SFWMD, 1994). Blaney-Criddle is currently used to estimate supplemental crop requirements in the District's CUP program. Details of demand assumptions are described in **Appendix B.**

In the base cases and alternatives, agricultural demands in the Caloosahatchee Basin were projected using the same method applied in the Restudy. The projected demands in 2020 are 25 percent greater than in 1995. Refer to the *Caloosahatchee Water Management Plan* (SFWMD, 2000d) for more information regarding assumptions for integrated surface and ground water model.

Inclusion of Restudy Components

The second primary difference between the simulations is inclusion of future projects and components. The LEC 2020 with Restudy simulation only includes those Restudy components expected to be completed by 2020. According to the Restudy Implementation Plan (USACE and SFWMD, 1999), all components are to be completed at that time except for the Lakebelt Storage Areas. Only half of the total volume of the

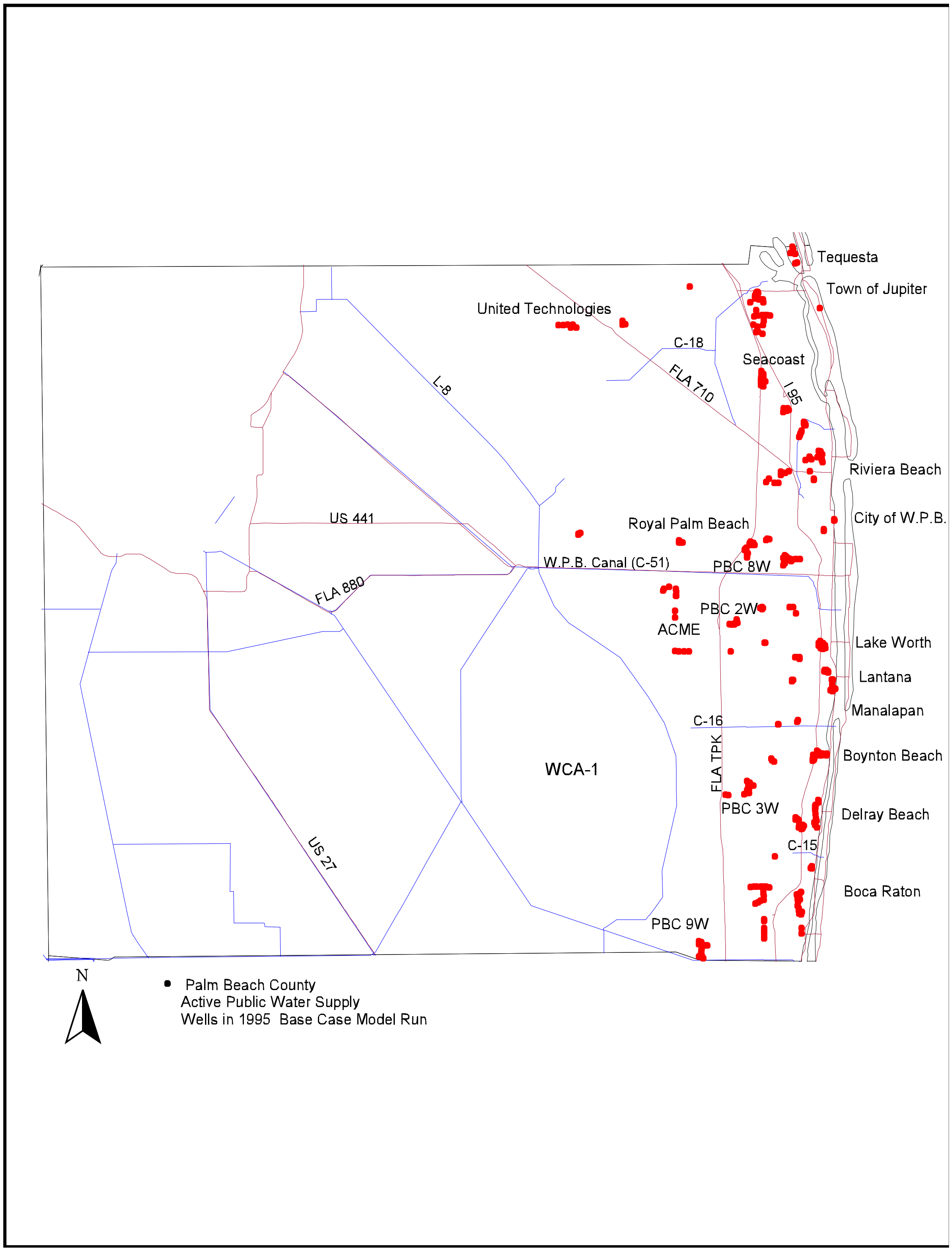

Figure 26. Active Palm Beach County Public Water Supply Wells in 1995 Base Case Model Simulation.

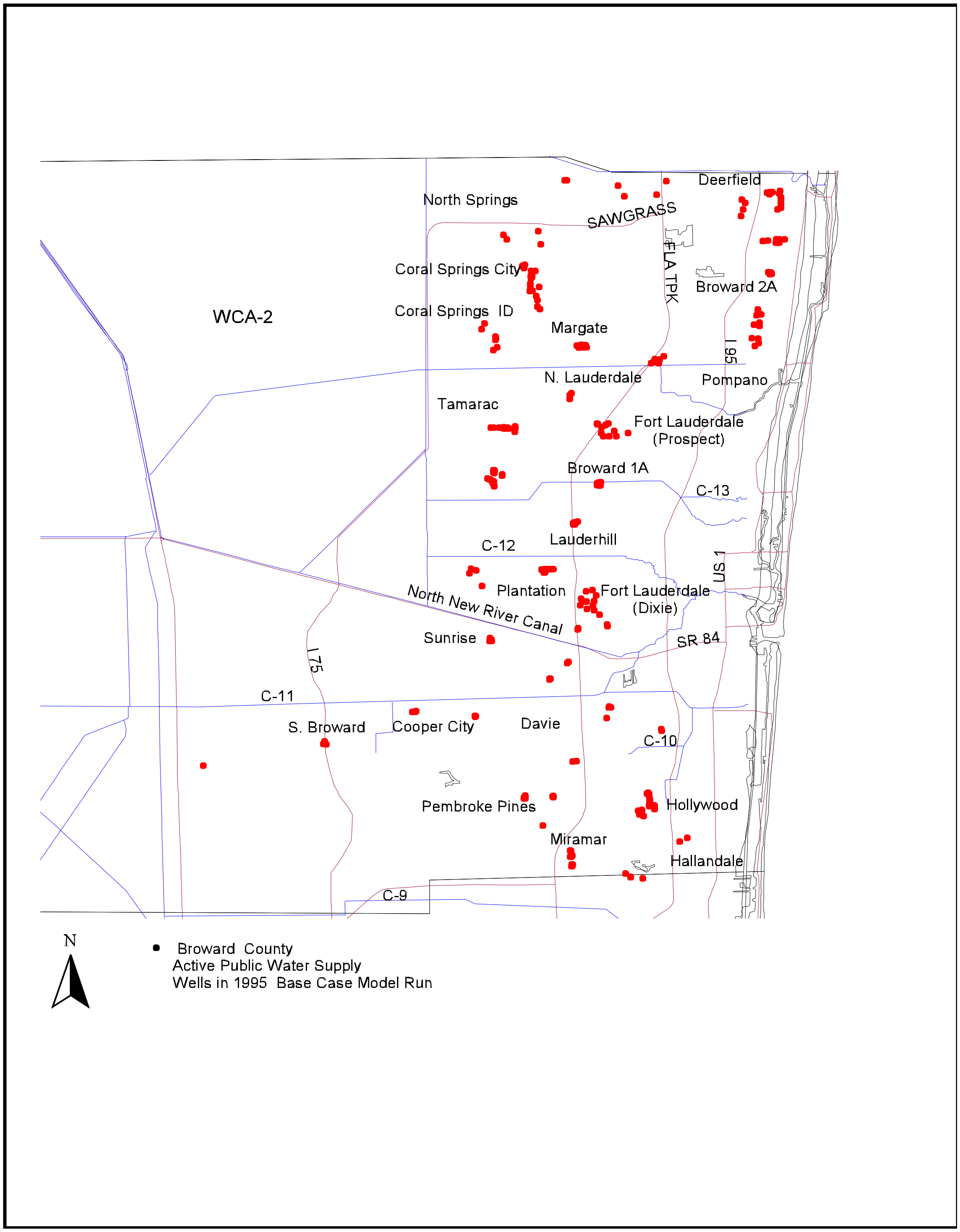

Figure 27. Active Broward County Public Water Supply Wells in 1995 Base Case Model Simulation.

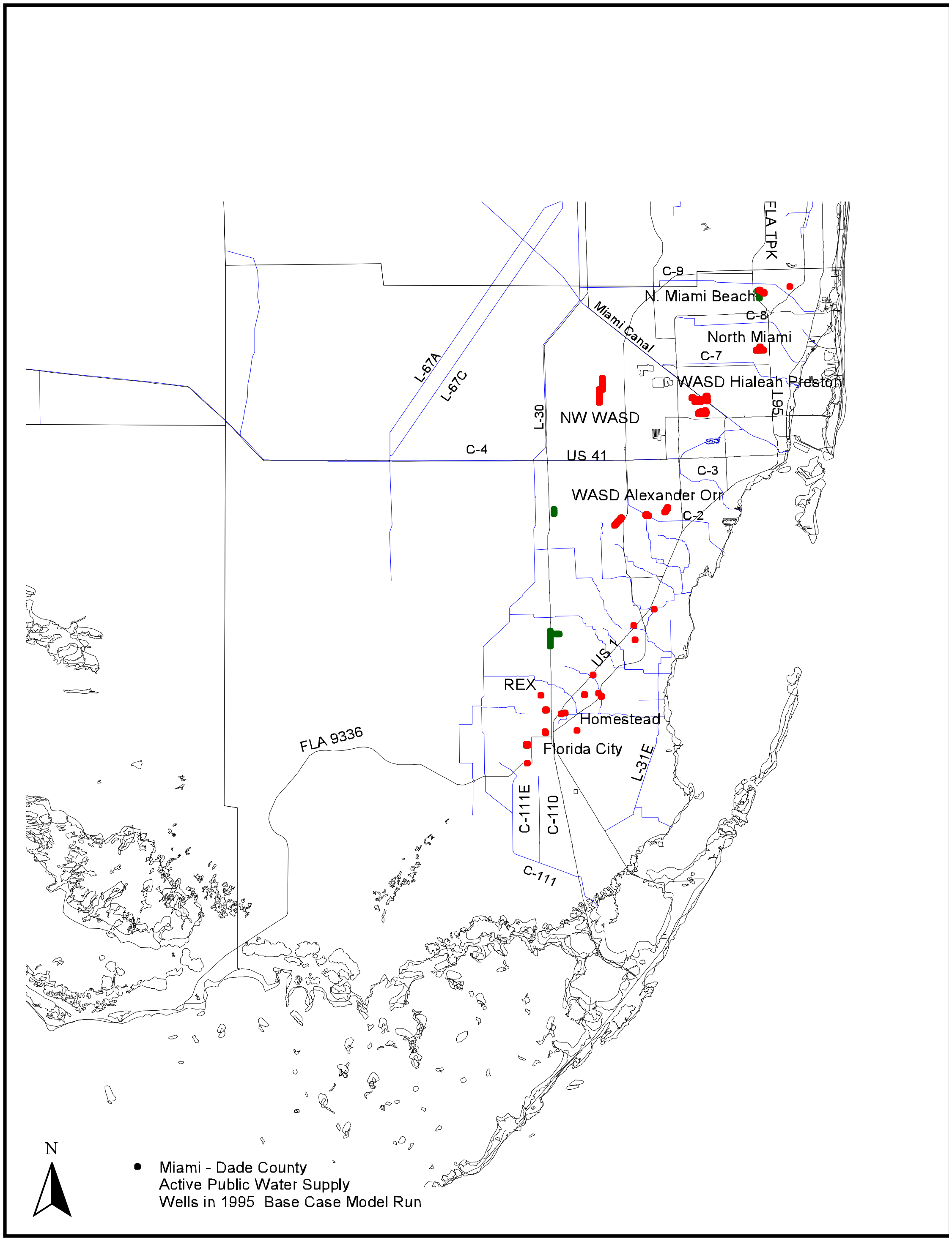

Figure 28. Active Miami-Dade County Public Water Supply Wells in 1995 Base Case Model Simulation.

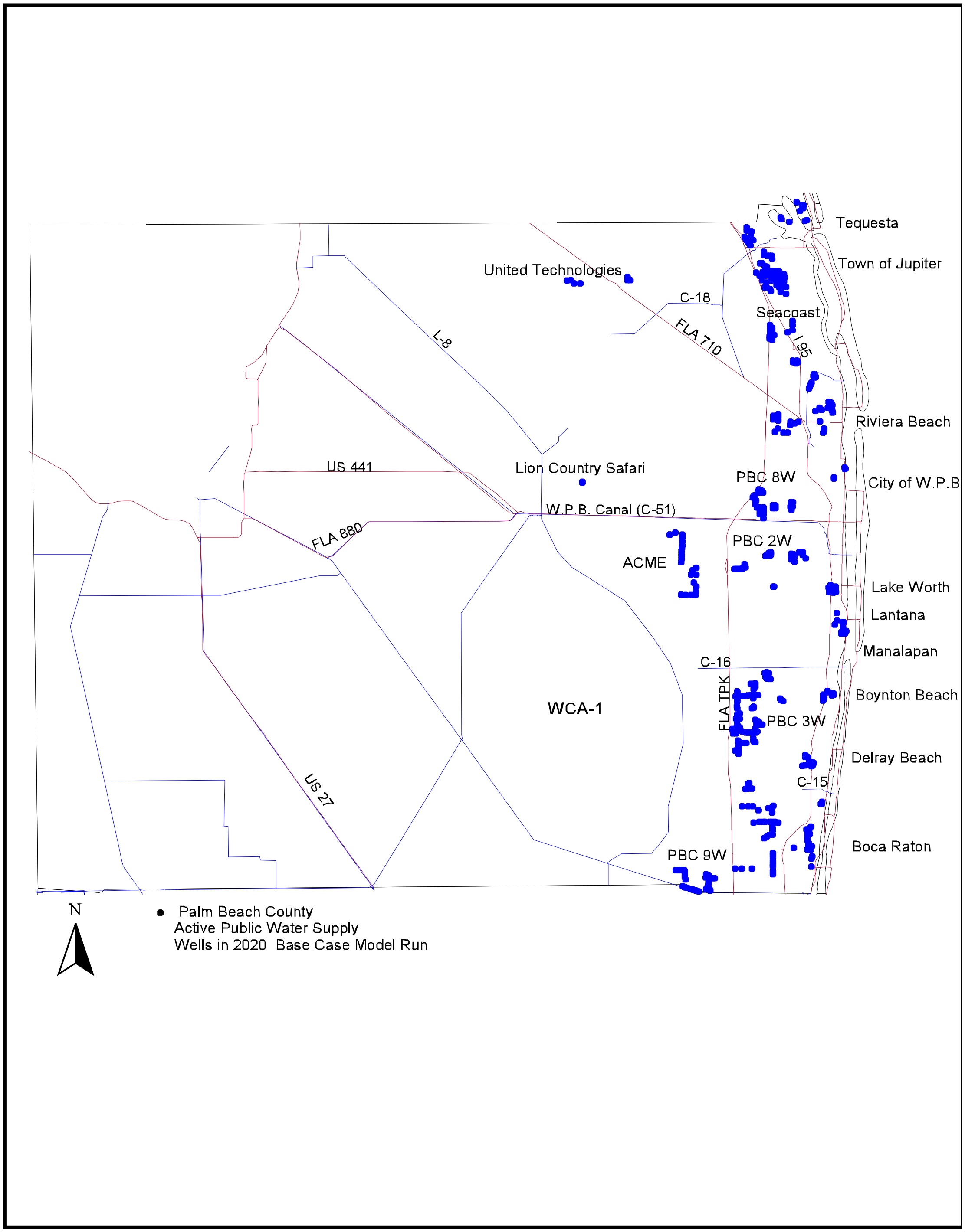

Figure 29. Active Palm Beach County Public Water Supply Wells in 2020 Base Case Model Simulation.

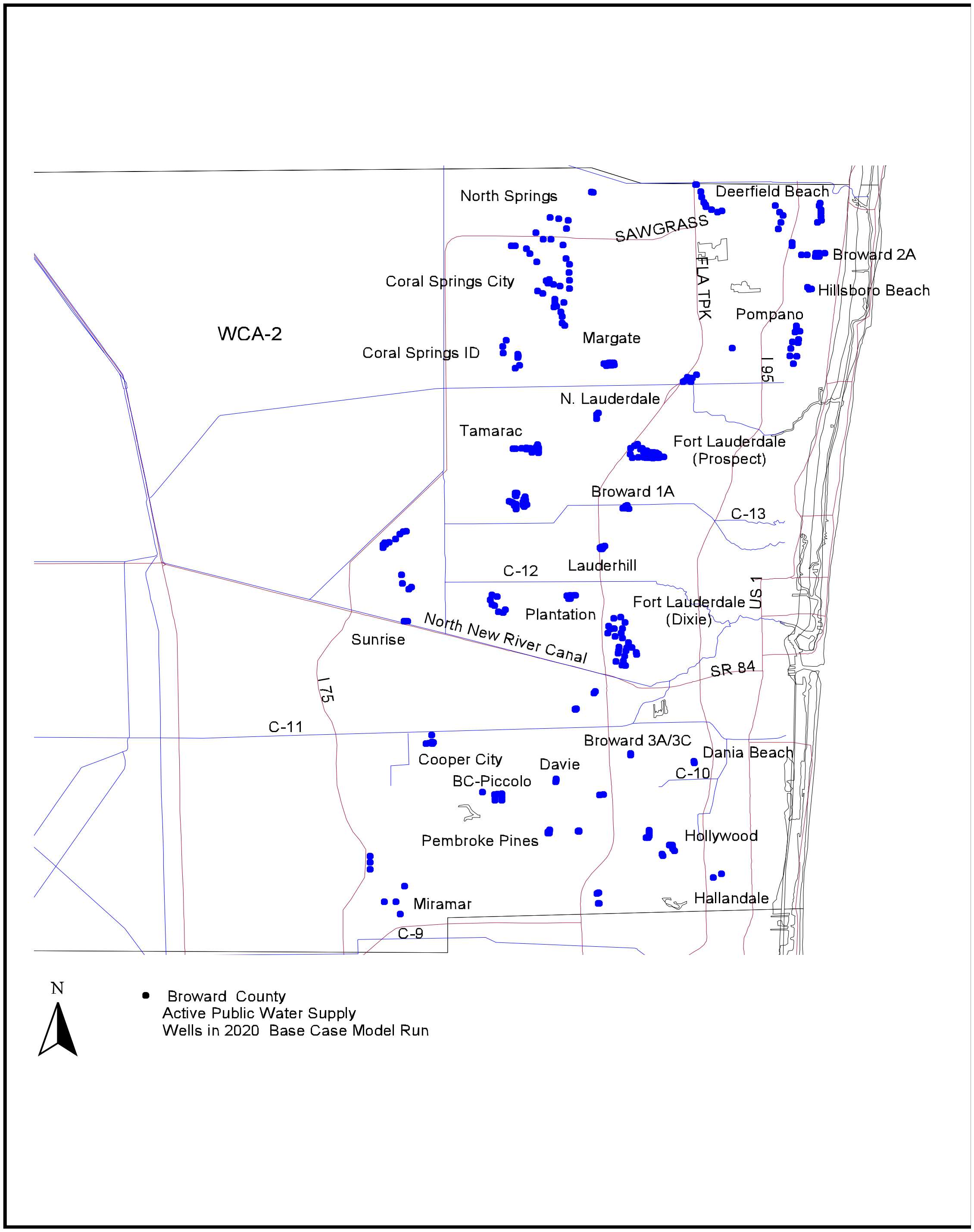

Figure 30. Active Broward County Public Water Supply Wells in 2020 Base Case Model Simulation.

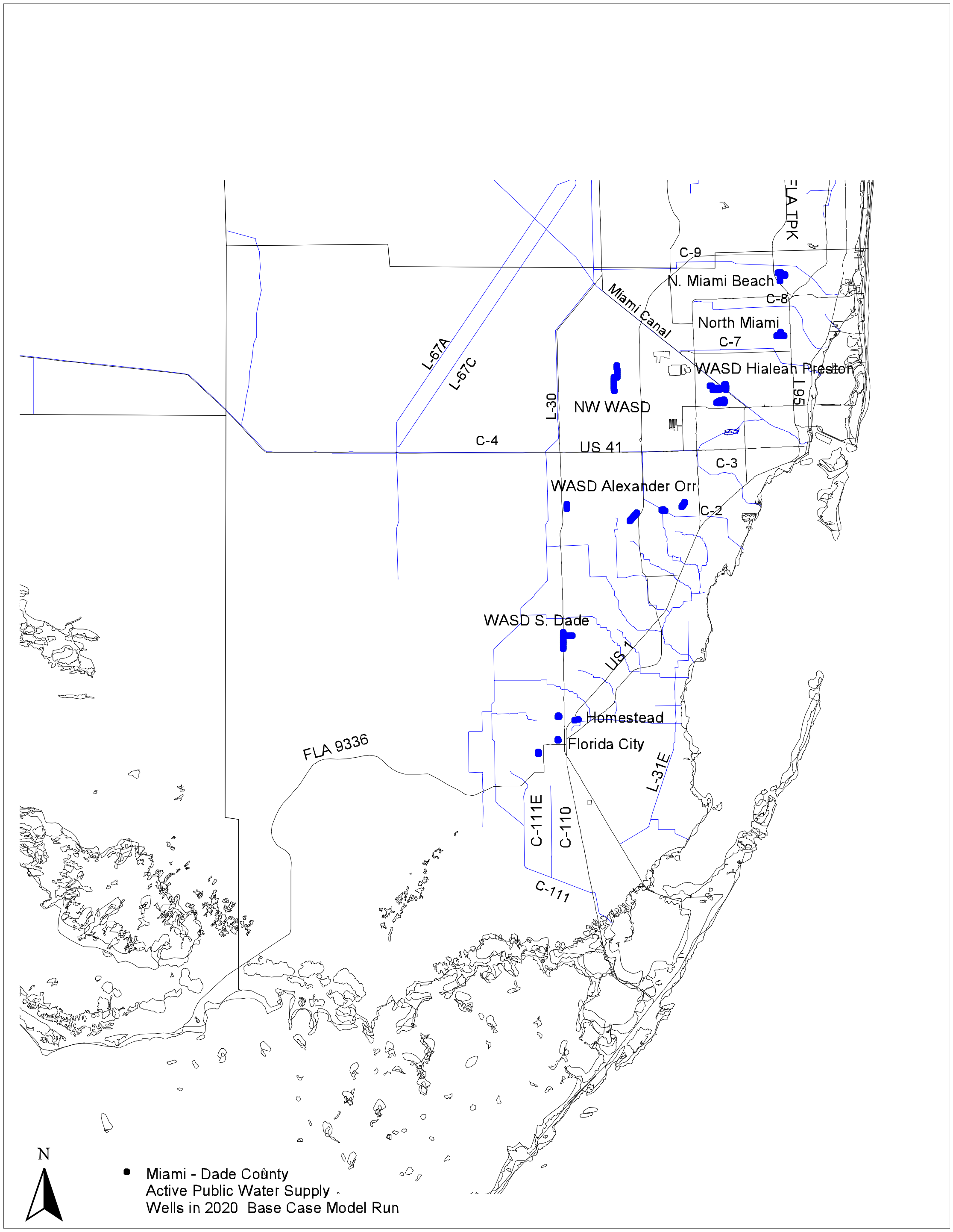

Figure 31. Active Miami-Dade County Public Water Supply Wells in 2020 Base Case Model Simulation.

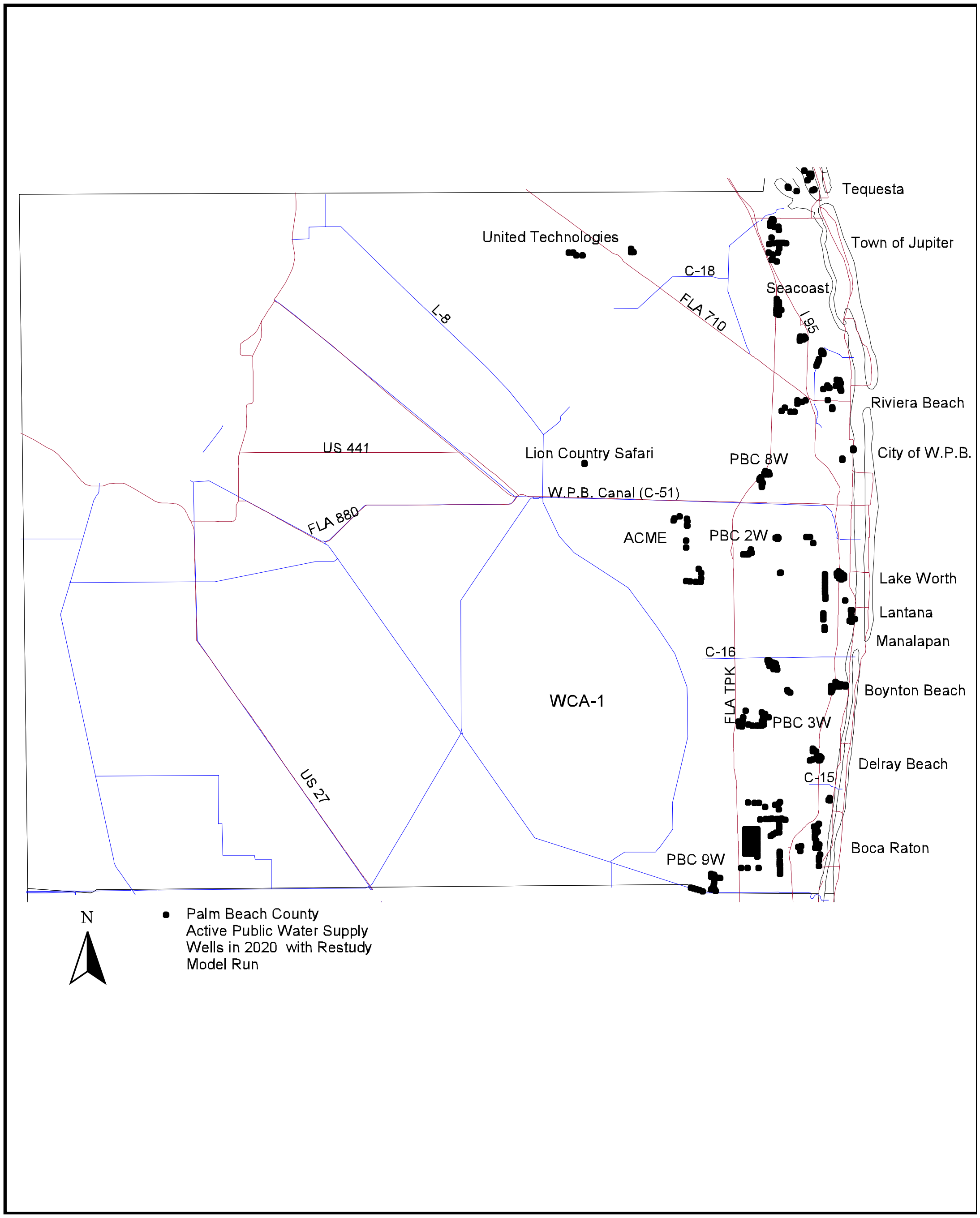

Figure 32. Active Palm Beach County Public Water Supply Wells in 2020 with Restudy Model Simulation.

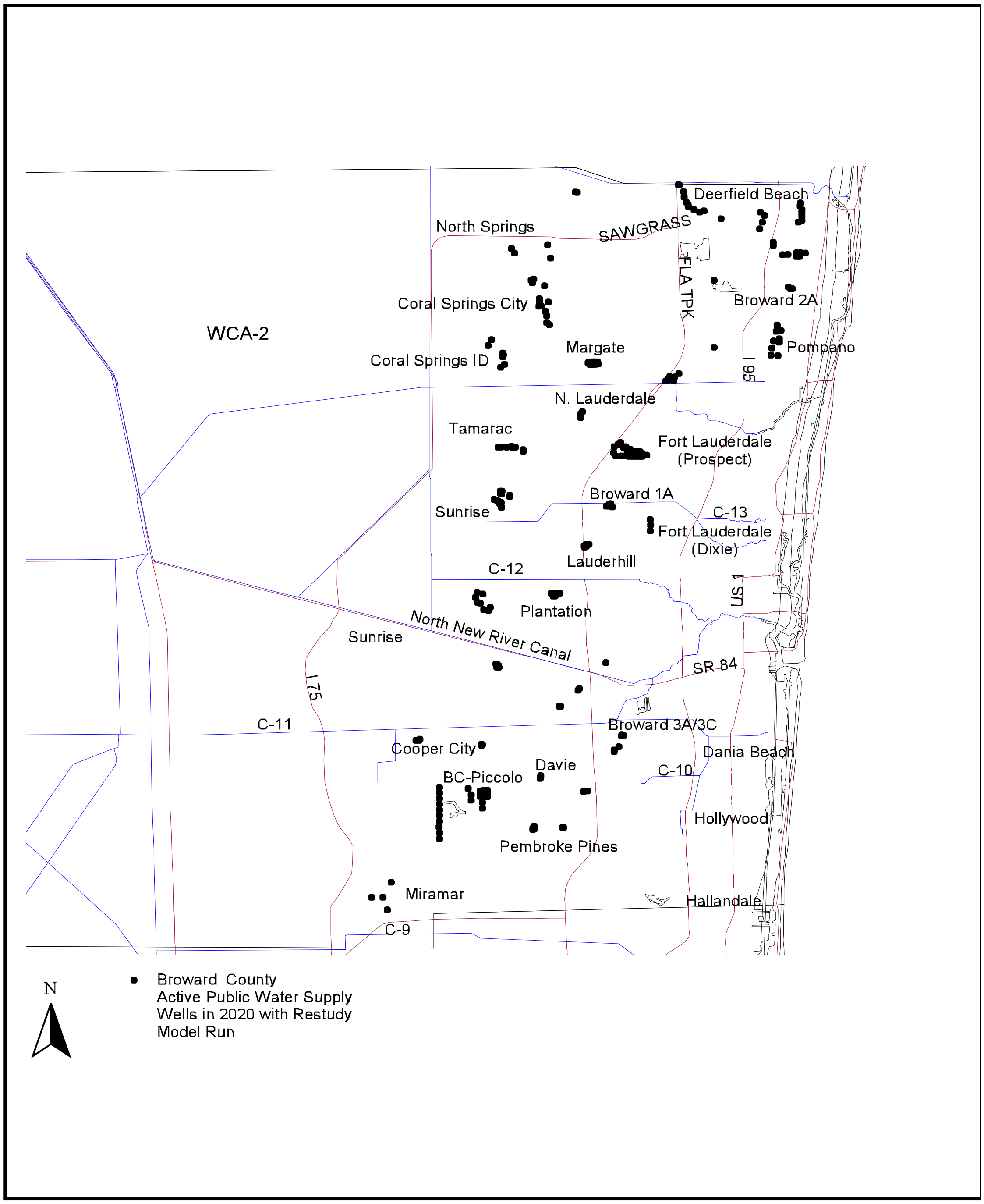

Figure 33. Active Broward County Public Water Supply Wells in 2020 with Restudy Model Simulation.

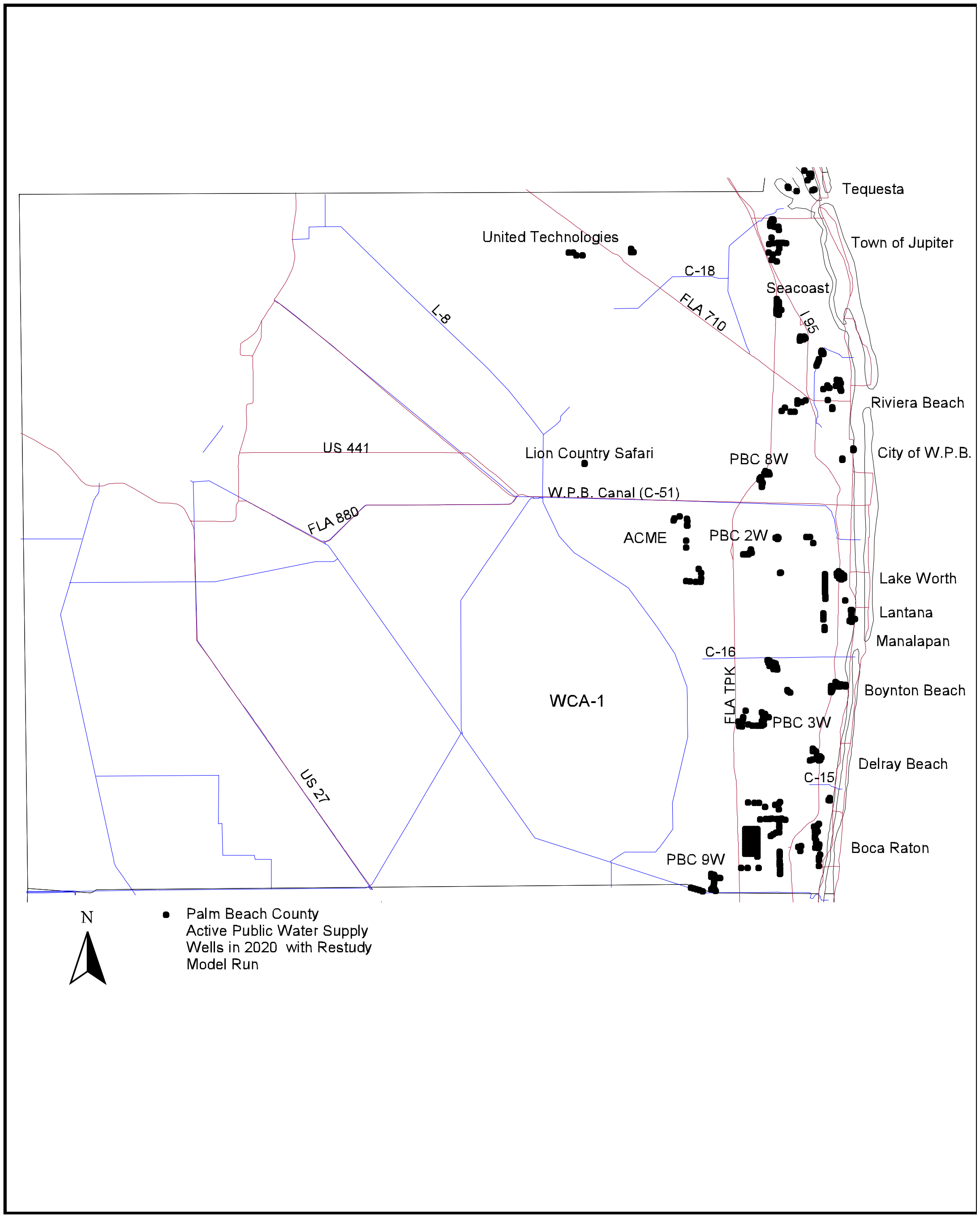

Figure 34. Active Miami-Dade County Public Water Supply Wells in 2020 with Restudy Model Simulation.

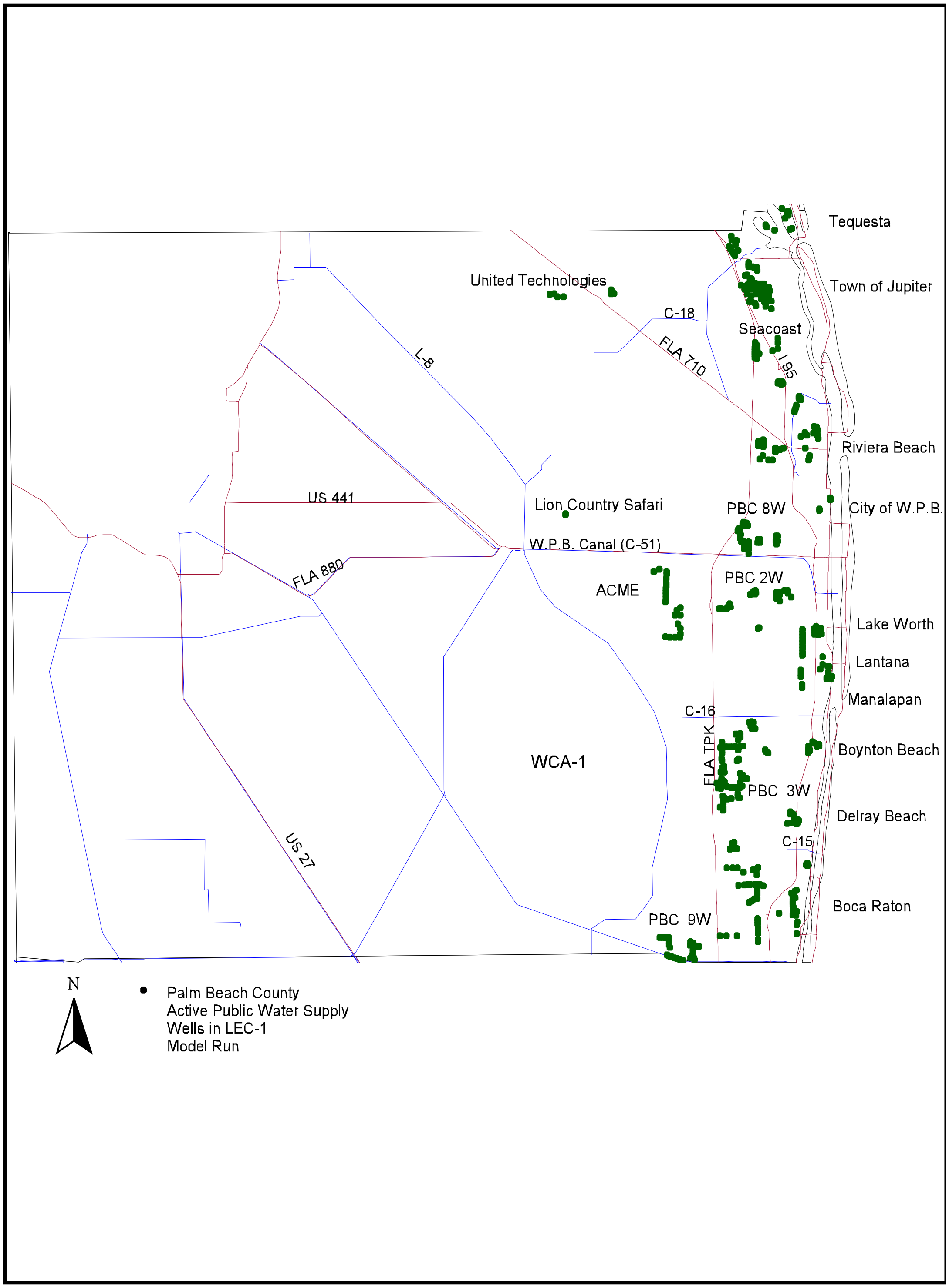

Figure 35. Active Palm Beach County Public Water Supply Wells in LEC-1 Model Simulation.

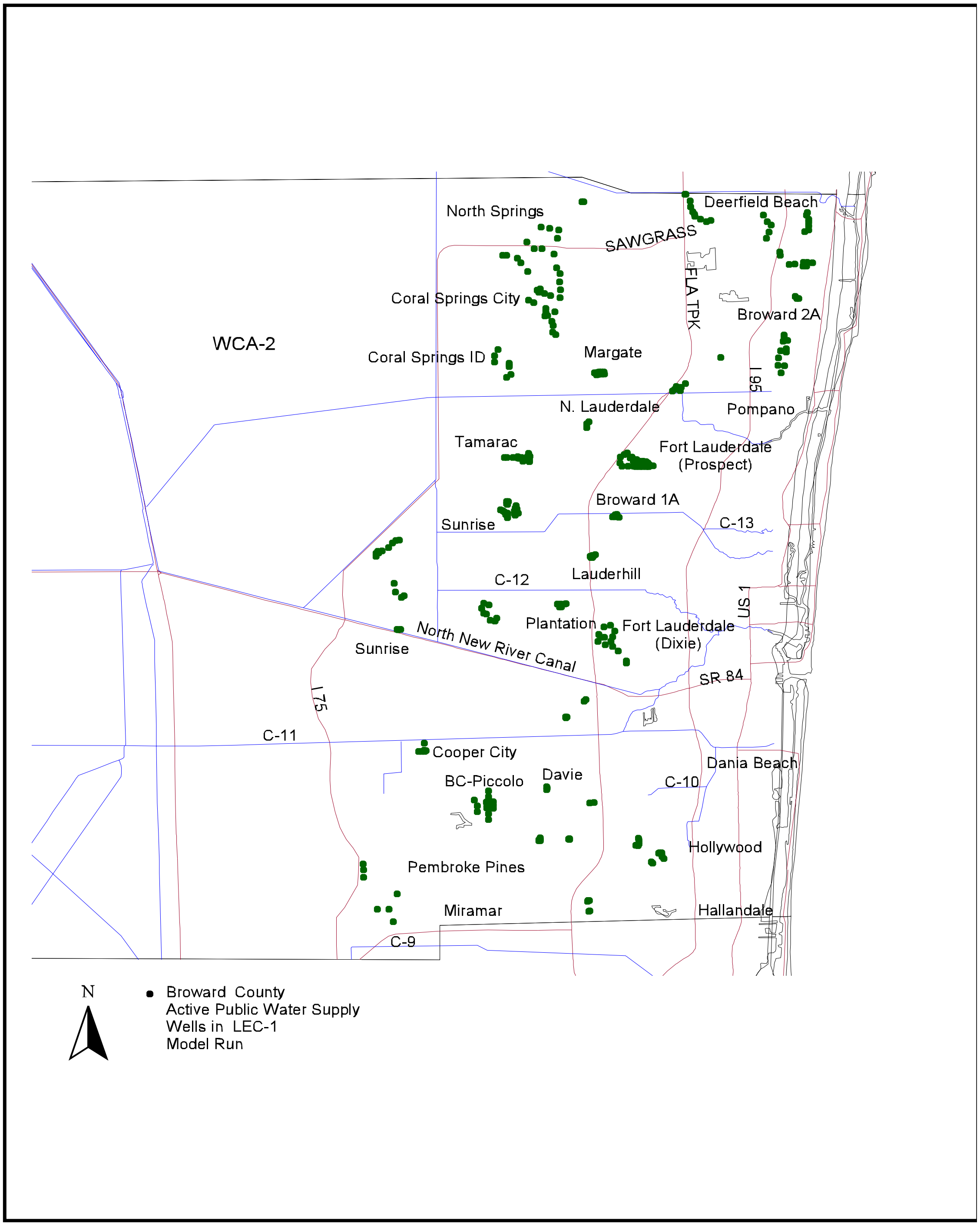

Figure 36. Active Broward County Public Water Supply Wells in LEC-1 Model Simulation.

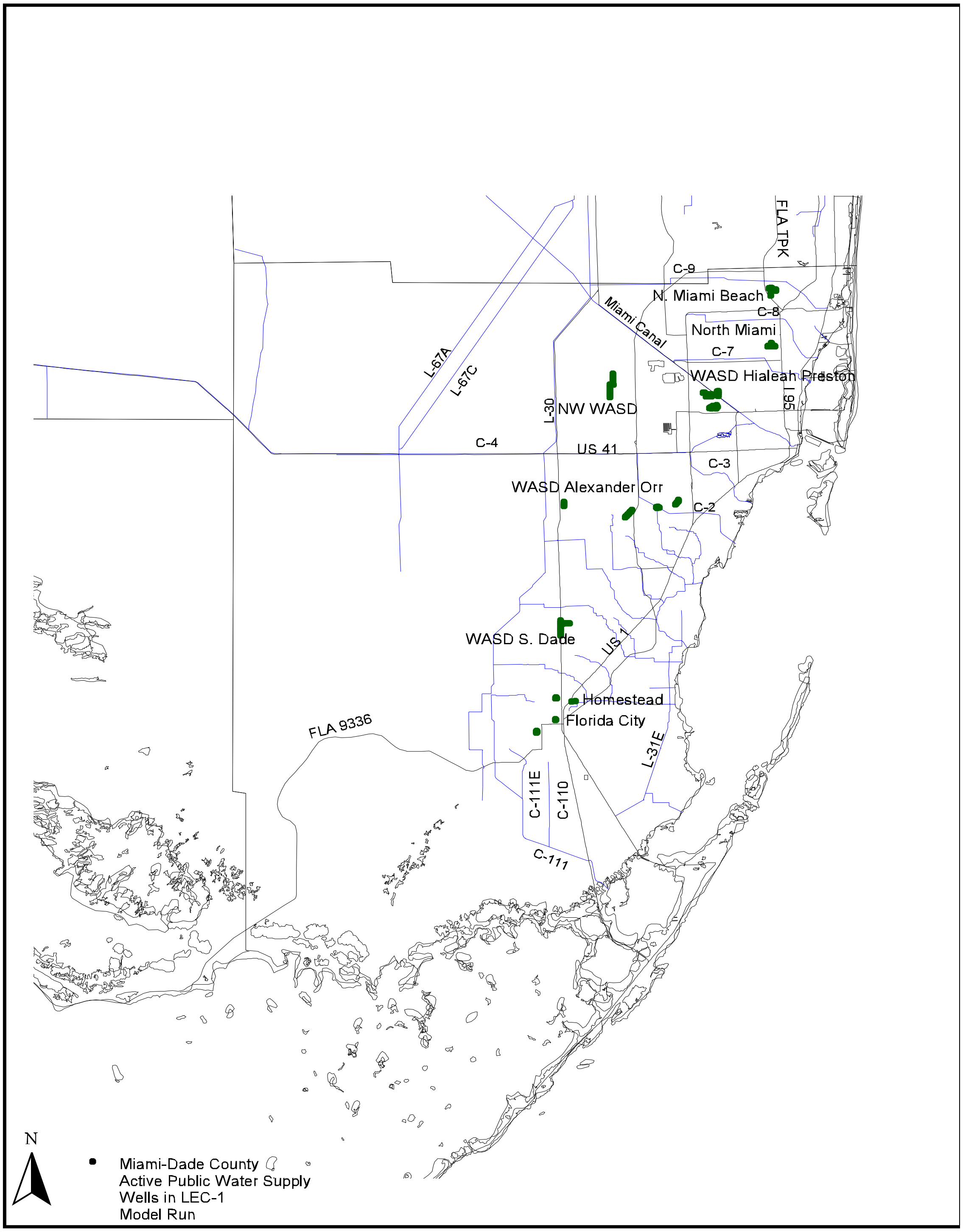

Figure 37. Active Miami-Dade County Public Water Supply Wells in LEC-1 Model Simulation.

North and Central Lakebelt projects, will be available in 2020. A list of the components in the LEC 2020 with Restudy simulation distinguishes between the Restudy components simulated in the SFWMM and those simulated in the subregional ground water models (**Table 7).**

Lake Okeechobee and Water Conservation Area Schedules

Changes in the Lake Okeechobee and WCAs schedules can have significant impacts on how outflows from the lake are managed to meet multiple purposes. The LEC 1995 Base Case relies upon the current U.S. Army Corps of Engineers (USACE) approved schedules to manage water in the lake and WCAs, while the LEC 2020 Base Case anticipates implementation of the Water Supply and Environmental (WSE) schedule on the lake and rainfall driven schedules for the WCAs and Everglades National Park. The LEC 2020 with Restudy simulation follows the precedent and relies upon rainfall driven schedules for the WCAs, but uses a modified “Run 25" schedule for the lake. When comparing results, the changes in operations and schedules have a significant positive impact on the ability to meet performance targets.

Current and Future Land Use

One of the model assumptions is how land is used, whether it is covered with houses and roads or is a natural wetland. The type of land use applied in the model most directly affects how the models handle evapotranspiration and overland flow or recharge. Three land use databases were developed for the *LEC Regional Water Supply Plan* analysis: 1) 1995 Land Use, which is based on interpretation of aerial surveys; 2) 2020 Land Use, which is an interpretation of the county comprehensive land use plans; and 3) 2020 with Restudy Land Use, which is the same as the 2020 land use except that it has been modified to reflect construction of the Restudy projects.

Incremental Simulations

The purpose of this analysis was to understand how the system performs in the interim period between now and 2020. Incremental years, 2005, 2010, and 2015, were selected to provide a snapshot of how the system would perform with partial completion of the Restudy projects and if the ability to meet the 1-in-10 year level of certainty criteria improves over time. This analysis consisted of identifying the components that were scheduled to be complete and fully operational by the end of each year selected (**Table 8)**. These components were then modeled to evaluate whether the sequencing would cause ecological or water supply conditions worse than the 1995 Base Case or improve performance in the interim period. The modeling analysis and evaluation of the components utilized the same performance measures as the base cases and LEC-1 analyses. This analysis was used to identify problem areas and confirm that the original implementation schedule developed for Restudy was constructed in a logical order that furthered the goals and objectives of the *LEC Regional Water Supply Plan.*

Table 7. Components Included in LEC 2020 with Restudy Model Simulations.

Component Name	2020 w/Restudy Components in Regional SFWMM v3.7	2020 w/Restudy Components in Subregional Ground Water Models
Indian River Lagoon		
C-44 Basin Storage Reservoir[a]	X	
C-23,C-24, C-25, North and South Fork Reservoir[a]	X	
Everglades Agriculture Area		
EAA Reservoirs[a]	X	
Lake Okeechobee Headwaters Storage		
Taylor Creek Nubbin Slough[a]	X	
North of Lake Okeechobee Storage[a]	X	
Caloosahatchee River Basin		
C-43 Basin Storage and ASR[a]	X	
Caloosahatchee Backpumping with STA[a]	X	
Water Preserve Area Components		
C-9 STA/Impoundment	X	X
Western C-11 Impoundment/Diversion	X	X
Dade/Broward Levee/Pennsuco	X	X
Hillsboro Impoundment and ASR (a.k.a. Site 1 Impoundment)	X	X
ACME Basin B Discharge	X	X
Protect Wetlands (Strazulla)	X	X
Pal-Mar/Corbett Hydroperiod Restoration	X	X
C-17 Backpumping & Treatment	X	X
C-51 Backpumping & Treatment	X	X
Bird Drive Recharge Area	X	X
Levee Seepage Management		
L31N Levee Improvements	X	X
WCA-3A and WCA-3B Seepage Management	X	X
S356 Structures	X	X
C-111 Operational Modifications	X	X
Storage with ASR Components		
L-8 Basin	X	X
C-51 and Southern L-8 Reservoir	X	X
C-51 Region Ground Water ASR	X	X
Agricultural Reserve Reservoir and ASR	X	X
Lakebelt Storage and Conveyance		
Central Lakebelt Storage Area Phase 1[b]	X	X
WCA-3B Flows to Central Lakebelt Storage Area	X	X
WCA-3A and WCA-3B Flows to Central Lakebelt	X	X
WCA-2 flows to Central Lakebelt Storage Area	X	X
North Lakebelt Storage Area Phase 1[b]	X	X
Water Conservation Areas and Everglades National Park		
Holey Land Regulation Schedule[a]	X	
Rotenberger Regulation Schedule[a]	X	

Table 7. Components Included in LEC 2020 with Restudy Model Simulations.**(Continued)**

Component Name	2020 w/Restudy Components in Regional SFWMM v3.7	2020 w/Restudy Components in Subregional Ground Water Models
WCA-1 Internal Structures	X	X
Reroute Miami-Dade Water Supply Deliveries	X	X
Additional S-345 Structures (L67 A)	X	X
WCA-3 Decompartmentalization and Sheetflow Enhancement	X	X
G404	X	X
Biscayne Bay		
Biscayne Bay Coastal Wetlands (FFF and OPE)	X	X
West Miami-Dade Reuse	X	X
South Miami-Dade Reuse	X	X
Lower East Coast		
LEC Utility Water Conservation		
Broward County Secondary Canal System	X	X
C-4 Divide Structure	X	X
C-111 N Spreader	X	X
Western Basin		
Miccosukee Water Management Plan[a]	X	
Flow to Northwest and Central WCA-3A[a]	X	
Big Cypress/L-28 Interceptor Modifications[a]	X	
Seminole Tribe Big Cypress Water Conservation Plan[a]		
Lake Okeechobee		
Lake Okeechobee ASR[a]	X	
Stand Alone OPEs		
Lake Okeechobee Watershed Water Quality Treatment Facility[c]		
LO Tributary Sediment Dredging[c]		
Lake Istopokga Regulation Schedule[c]		
Southern Golden Gates Hydrologic Restoration[c]		
Southern CREW Project[c]		
Lake Trafford Restoration[c]		
Lake Worth Lagoon Restoration[c]		
Pineland/Hardwood Hammocks[c]		
Melaleuca Erad. Project & Other Exotics[c]		
Florida Keys Tidal Restoration[c]		
Henderson Creek/Belle Meade Restoration[c]		
Winsburg Farms Wetlands[c]		
Lakes Park Restoration[c]		

a. Outside of the subregional ground water models' boundaries
b. 50 percent completed by 2021
c. Cannot be simulated with these types of hydrologic models

Table 8. Implementation Schedule for Restudy Components in Five-Year Increments.

Component Name	2005	2010	2015	LEC-1 Revised
Indian River Lagoon				
C-44 Basin Storage Reservoir		X	X	X
C-23,C-24		X	X	X
C-25, North and South Fork Reservoir		X	X	X
Everglades Agriculture Area				
EAA Reservoirs Phase 1		X	X	X
EAA Reservoirs Phase 2			X	X
Lake Okeechobee Headwaters Storage				
Taylor Creek Nubbin Slough		X	X	X
North of Lake Okeechobee Storage			X	X
Caloosahatchee River Basin				
C-43 Basin Storage and ASR		X[a]	X	X
Caloosahatchee Backpumping with STA[b]				
Water Preserve Area Components				
C-9 STA/Impoundment		X	X	X
West C-11 Diversion and Impoundment		X	X	X
Dade-Broward Levee/Pennsuco Wetlands		X	X	X
Hillsboro Impoundment		X	X	X
Hillsboro Impoundment ASR			X	X
ACME Basin B Discharge[c]		X	X	X
Protect Wetlands (Strazulla)		X	X	X
Pal-Mar/Corbett Hydroperiod Restoration		X	X	X
C-17 Backpumping and Treatment		X	X	X
C-51 Backpumping and Treatment		X	X	X
Bird Drive Recharge Area			X	X
Levee Seepage Management				
L31N Levee Seepage Management and Relocation		X	X	X
WCA-3A and WCA-3B Seepage Management		X	X	X
S-356 Structures		X	X	X
Storage with ASR Components				
L-8 Basin Modifications			X	X
C-51 and Southern L-8 Reservoir			X	X
C-51 Regional Groundwater ASR			X	X
Agricultural Reserve Reservoir and ASR			X	X
Lakebelt Storage and Conveyance				
Central Lakebelt Storage Area[d]				X
Central Lakebelt Storage Area				
WCA-3B Flows from Central Lakebelt			X	X
WCA-3A and WCA-3B flows to Central Lakebelt				X
WCA 2 flows to Central Lakebelt Storage				X
North Lakebelt Storage Area[d]				X
North Lakebelt Storage Area				
Water Conservation Areas and Everglades National Park				
Reroute Miami-Dade Water Supply Deliveries		X	X	X

Table 8. Implementation Schedule for Restudy Components in Five-Year Increments.**(Continued)**

Component Name	2005	2010	2015	LEC-1 Revised
Additional S-345 Structures (L-67 A)		X	X	X
WCA-3 Decompartmentalization and Sheetflow Enhancement		X	X	X
WCA-3 Decompartmentalization and Sheetflow Enhancement				X
Holey Land Regulation Schedule		X	X	X
Rotenberger Regulation Schedule	X	X	X	X
WCA-1 Internal Structures	X	X	X	X
C-111 Operational Modifications	X	X	X	X
G-404		X	X	X
C-111 Spreader Canal		X	X	X
Biscayne Bay				
Biscayne Bay Coastal Wetlands (FFF&OPE)				X
West Miami-Dade Reuse[e]				X
South Miami-Dade Reuse				X
Lower East Coast				
LEC Utility Water Conservation				
Broward County Secondary Canal System		X	X	X
C-111 N Spreader		X	X	X
C-4 Divide Structure	X	X	X	X
Western Basin				
Miccosukee Water Mgmt Plan		X	X	X
Flow to Northwest and Central WCA-3A		X	X	X
Big Cypress/L-28 Interceptor Modifications				X
Seminole Tribe Big Cypress Water Conservation Plan		X	X	X
Lake Okeechobee				
Lake Okeechobee ASR			X (50%)	X
Stand Alone OPES				
Lake Okeechobee Watershed Water Quality Treatment Facility[c]				
Lake Okeechobee Tributary Sediment Dredging/Phosphorus Removal				
Lake Istopokga Regulation Schedule				
Southern Golden Gates Hydrologic Restoration				
Southern CREW Project				
Lake Trafford Restoration				
Lake Worth Lagoon Restoration				
Pineland/Hardwood Hammocks				
Melaleuca and Other Exotics Eradication Project				
Florida Keys Tidal Restoration				
Henderson Creek/Belle Meade Restoration				
Winsburg Farms Wetlands				
Lakes Park Restoration				

a. Storage only
b. Modeled in CWMP
c. Not simulated by SFWMM
d. Actually 2/21
e. 50 percent total capacity in LEC-1 and LEC-1 Revised

Assumptions for Incremental Simulations

The SFWMM simulated incremental simulations to understand how the system performs through time at five year increments as features of the plan are constructed or implemented. The 1995 Base Case and LEC-1 provide beginning and end points to evaluate progress over time as components are implemented. The beginning and end points were revised to make comparisons to the incremental simulations valid, i.e. incorporate similar model assumptions so the only variables were the Restudy projects themselves. These simulations are referred to as the 1995 Revised Base and the LEC-1 Revised, respectively. **Table 9** references the acronyms used in the model results graphics

Table 9. Acronyms for SFWMM Incremental Simulations.

SFWMM Simulation	SFWMM Acronym
1995 Revised Base Case	95BSRR
2005	2005R
2005 SSM Scenario	2005 SSM
2010	2010R
2015	2015R
LEC-1 Revised	LEC-1R or 2020R

found in **Appendix H**. Agricultural, urban, and environmental demands increased over time as demands grow and water supplies expand**.** A summary of the modeling assumptions for the incremental simulations can be found in **Table 10.**

Assumptions for 2005 SSM Scenario

A 2005 SSM Scenario was also simulated with the SFWMM as part of the incremental simulation analysis. The purpose of this scenario was to determine the sensitivity of modifications to the regional system to Lake Okeechobee's operations and its ability to meet water supply demands. In the 2005 SSM Scenario, the Lake Okeechobee Supply-Side Management criteria were modified. Other alternatives to achieve this goal will also be considered in solution development. The Supply-Side Management restrictions were designed to be conservative and retain water in the regional system to meet unforeseen demands later in the drought or dry season. The conservative approach may be too restrictive for future conditions, especially considering additional demands placed on the lake since the Supply-Side Management criteria was developed. By 2005, several new demands are placed on Lake Okeechobee, but no regional storage features are available to meet some of these new demands. The increased demands in 2005 include the Everglades Construction Project, the Rainfall Driven Schedules for the WCAs, and Caloosahatchee Basin and lower Lake Istokpoga supplemental irrigation demands. To meet the existing and future demands on Lake Okeechobee, the stage that triggers supply-side management was lowered by approximately one-half of a foot. The May target stage of 11.5 ft NGVD remained constant.

Table 10. Comparison of Assumptions for Incremental Model Simulations by the SFWMM.

Feature	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Land Use for Urban and Agricultural Areas	Best available information for 1995 Condition	Best available information for 1995 Condition; adjusted to Reflect Construction of STAs	2020 projections based on county comprehensive plans; adjusted to reflect construction of STAs and appropriate components in Restudy	2020 projections based on county comprehensive plans; adjusted to reflect construction of STAs and appropriate components in Restudy	2020 projections based on county comprehensive plans; adjusted to reflect construction of STAs and appropriate components in Restudy
Vegetation Cover for Natural Areas	Same as 1995; best available information; generally reflects conditions between 1990-1995	Same as 1995; best available information; generally reflects conditions between 1990-1995	Same as 1995; best available information; generally reflects conditions between 1990-1995	Same as 1995; best available information; generally reflects conditions between 1990-1995	Same as 1995; best available information; generally reflects conditions between 1990-1995
Other LOSA/EAA Mean Annual Supplemental Irrigation Demands	217,000/371,000 ac-ft	234,000[a]/351,000 ac-ft	260,000/332,000 ac-ft	225,000/327,000 ac-ft	229,000/333,000 ac-ft
Lake Okeechobee Regulation Schedule	WSE Schedule	WSE Schedule	Modified WSE Schedule[b]	Modified WSE Schedule[b]	Modified WSE Schedule[b]
Lake Okeechobee Supply-Side Management for LOSA	Current schedule	Current schedule	Modified[c]	Modified[c]	Modified[c]
Caloosahatchee River Basin Demands (includes municipal demands and supplies)	Demands for 1995 estimated using AFSIRS method per CWMP	Demands for 2005 estimated using AFSIRS method per CWMP	Demands for 2010 estimated using AFSIRS method per CWMP	Supplies limited to Restudy deliveries of approx. 29,000 ac-ft/yr at S-77	Supplies limited to Restudy deliveries of approx. 29,000 ac-ft/yr at S-77
Caloosahatchee Basin Backpumping	Not applicable	Not applicable	Set to zero as per CWMP	Set to zero as per CWMP	Set to zero as per CWMP
St Lucie (C-44) Reservoir	Not constructed	Not constructed	Constructed and operated as per Indian River Lagoon Feasibility Study	Constructed and operated as per Indian River Lagoon Feasibility Study	Constructed and operated as per Indian River Lagoon Feasibility Study
Seminole-Brighton Tribe Demands	28,500 ac-ft annual average; maximum 44,000 ac-ft/yr	28,500 ac-ft annual average; maximum 44,000 ac-ft/yr	28,500 ac-ft annual average; maximum 44,000 ac-ft/yr	28,500 ac-ft annual average; maximum 44,000 ac-ft/yr	28,500 ac-ft annual average; maximum 44,000 ac-ft/yr
STAs Associated with the EAA	Yes	Yes	Yes	Yes	Yes
EAA Runoff Reduction and Make-Up Water BMP	No runoff reduction or make-up water delivered	No runoff reduction or make-up water delivered	No runoff reduction or make-up water delivered	No runoff reduction or make-up water delivered	No runoff reduction or make-up water delivered
Make-Up Water Associated with BMPs from Lake Okeechobee	No	No	No	No	No
EAA Reservoirs	Not constructed	Not constructed	Redirect Miami, North New River, and Hillsboro basins' runoff to EAA Reservoir; 30,000 acres for EAA water supply and 20,000 acres for environmental water supply; used to meet demand in all major EAA basins (including West Palm Beach)	Redirect Miami, North New River, and Hillsboro basins' runoff to EAA Reservoir; 30,000 acres for EAA water supply and 20,000 acres for environmental water supply; used to meet demand in all major EAA basins (including West Palm Beach)	Redirect Miami, North New River, and Hillsboro basins' runoff to EAA Reservoir; 30,000 acres for EAA water supply and 20,000 acres for environmental water supply; used to meet demand in all major EAA basins (including West Palm Beach)

Table 10. Comparison of Assumptions for Incremental Model Simulations by the

Feature	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
WCA-1 Schedule	Interim regulation schedule	Interim regulation schedule	Interim regulation schedule	Interim regulation schedule	Interim regulation schedule
WCA-2A Schedule	Current regulation schedule	Current regulation schedule	Rainfall driven schedule	Rainfall driven schedule	Rainfall driven schedule
WCA-2B, WCA-3A, and WCA-3B Schedules	Current regulation schedule	Rainfall driven schedule	Rainfall driven schedule	Rainfall driven schedule	Rainfall driven schedule
ENP Operations	Experimental Rainfall Delivery Plan via S-12s and S-333	As per MWD Project GDM w/o tailgated constraints on L-29	As per MWD Project GDM w/o tailwater constraints on L-29	As per Restudy	As per Restudy
LECSA Population	4,755,776 persons	5,304,831 persons	5,853,886 persons	6,402,941 persons	6,951,998 persons, as per LEC utility survey
LECSA Public Water Supply Demands on Surficial Aquifer System and Surface Water	Actual 1995 demands: 286,429 mgy (784.10 mgd)	325,464 mgy (892.5 mgd)	364,927 mgy (999 mgd)	403,948 mgy (1,106.5 mgd)	Projected demands based on LEC utility survey: 443,411 mgy (1,214.8 mgd)
LECSA Public Water Supply Wellfield Distribution	Actual 1995 locations	Modifications to eleven utilities' preferred wellfield locations (based on LEC utility survey)	Modifications to eleven utilities' preferred wellfield locations (based on LEC utility survey)	Modifications to eleven utilities' preferred wellfield locations (based on LEC utility survey)	Modifications to eleven utilities' preferred wellfield locations (based on LEC utility survey)
LECSA Water Shortage Policy	Yes	Yes	Yes	Yes	Yes
LEC Irrigation Demands on Surficial Aquifer System	Based on land use and climatic variation	Based on projected 1995 land use and climatic variation	Same as LEC-1 Revised	Same as LEC-1 Revised	Based on projected 2020 land use and climatic variation
Operational Adjustments to Meet MFL for Biscayne Aquifer	No	Canal operation criteria (in NGVD): C-51@S-155 - 7.80 C-16@S-40 - 7.80 C-15@S-41 - 7.80 C-6@S-26 - 2.00 C-4@S-25B - 2.20 C-2@S-22 - 2.20	Canal operation criteria (in NGVD): C-51@S-155 - 7.80 C-16@S-40 - 7.80 C-15@S-41 - 7.80 C-6@S-26 - 2.00 C-4@S-25B - 2.20 C-2@S-22 - 2.20	Canal operation criteria (in NGVD): C-51@S-155 - 7.80 C-16@S-40 - 7.80 C-15@S-41 - 7.80 C-6@S-26 - 2.00 C-4@S-25B - 2.20 C-2@S-22 - 2.20	Canal operation criteria (in NGVD): C-51@S-155 - 7.80 C-16@S-40 - 7.80 C-15@S-41 - 7.80 C-6@S-26 - 2.00 C-4@S-25B - 2.20 C-2@S-22 - 2.20
L-8 Basin Project	Not constructed	Not constructed	Not constructed	As per Restudy	As per Restudy
Broward Secondary Canal Network	Not constructed	Partial, the northern portion only	As per Restudy	As per Restudy	As per Restudy
Miami-Dade Utility ASR	Not constructed	25 mgd	50 mgd	75 mgd	75 mgd
Miami-Dade Reuse	Not constructed	0 mgd	0 mgd	0 mgd	50 mgd West Facility; 131 mgd South Facility
Optimization of Regional ASR	Not applicable	Not applicable	Not applicable	Excess water from C-51 ASR and WPB Catchment Area ASR sent to meet EAA demands	Excess water from C-51 ASR and WPB Catchment Area ASR sent to meet EAA demands

a. Accounts for reduction due to construction of STAs and reservoirs
b. WSE modified to incorporate operations associated with Lake Okeechobee ASR, EAA reservoirs, and North of Lake Reservoir
c. Modified SSM accounts for storage available in reservoirs around Lake Okeechobee

Additional Assumptions of Base Cases, Alternatives, and Incremental Simulations

Modifications to assumptions in the SFWMM were made to improve performance and meet hydrologic targets. Additional assumptions were also made to update information included in the SFWMM to reflect best available information. These changes are discussed below. To identify which simulations incorporated these assumptions, refer to **Tables 6** and **10**.

Best Management Practice Make-Up Water

In previous analyses, it had been assumed that the implementation of Best Management Practices (BMPs) in the EAA would reduce the volume of runoff from the EAA to the Everglades by 20 percent. According to the Everglades Forever Act, and subsequent SFWMD rules, this reduction of flow must be offset by additional releases from Lake Okeechobee. Now that the BMPs have been in place for five full years actual runoff data have been analyzed to quantify the actual change in runoff attributable to the BMP program. An extensive review of the available data conducted under the auspices of the EAA Environmental Protection District indicates that no measurable reduction in runoff due to implementation of BMPs has occurred. Therefore, for the purposes of computer modeling to support the LEC Regional Water Supply Plan, no reduction in runoff and consequently no make-up water deliveries were simulated. Ongoing rulemaking by the District on the make-up water requirements will assess the quantity of runoff from the EAA, which will then be incorporated into future regional analyses.

Brighton Seminole Demands

The Brighton Seminole Tribe has an existing compact with the SFWMD for water deliveries from Lake Okeechobee to meet supplemental irrigation demands. In the *LEC Regional Water Supply Plan*, the demand varies seasonally and annually with a maximum annual demand of 44,000 acre-feet and an average annual demand of 28,500 acre-feet. These demands differ from what was assumed during the Restudy.

Caloosahatchee Demands

The Caloosahatchee demand projections used in the 1995 and 2020 base cases, LEC 2020 with Restudy, and LEC-1 were derived in the same fashion as those assumed in the Restudy modeling. The 1995 Base Case is based on historical demands and the 2020 demand projection is 25 percent greater than in 1995. The Restudy assumed a 40 percent increase in demands in 2050 compared to 1995. The future supplemental irrigation demands are met from Lake Okeechobee in the 2020 Base Case. In the LEC 2020 with Restudy and LEC-1 simulations, the future demands are met partially from the C-43 Reservoir and ASR facilities.

The demand projections that were developed for the *Caloosahatchee Water Management Plan* (*CWMP)* form the basis for the evaluation of demands in the

Caloosahatchee Basin in the incremental simulations. These demands were met from the lake in the 1995 Base Case Revised and the 2005 and 2010 incremental simulations. In the 2015 and LEC-1 Revised regional model simulations, the demands were met from the C-43 Reservoir and ASR system and a portion from Lake Okeechobee. In the incremental simulations, the demands in 2010, 2015, and LEC-1 Revised are capped at the same average annual volume that can be provided in the LEC 2020 with Restudy model simulation. In other words, the demands in the incremental simulations use the revised demands as projected by the *CWMP*, but they are met from within the Caloosahatchee Basin once the C-43 Reservoir is constructed.

Caloosahatchee Basin Backpumping to Lake Okeechobee

One major difference between the LEC 2020 with Restudy and LEC-1 model simulations is that in the LEC-1 simulation, no backpumping is assumed. This source of water to the lake is no longer considered available. This is also true for all incremental model simulations. This assumption will need further evaluation as the demand and runoff estimates developed by AFSIRS are reviewed by the Comprehensive Everglades Restoration Plan’s (CERP's) Restoration, Coordination, and Verification process (RECOVER).

Minimum Flows and Levels for the Biscayne Aquifer

The minimum levels for coastal canals to protect the Biscayne aquifer was recently developed (SFWMD, 2000e). These minimum levels correlate to operation levels for eleven coastal canals as indicated in **Tables 6** and **10**. These levels vary slightly from what was assumed during the Restudy.

Lake Istopokga Demands

Additional pastureland in the lower Lake Istopokga Basin is expected to be converted to sugar cane in the near future, resulting in new demands and runoff. Seasonally and annually varied demands and runoff from the lower Lake Istopokga Basin were used with an average annual demand of 12,000 acre-feet and an average annual runoff of 6,000 acre-feet. Modeling for the *LEC Regional Water Supply Plan* assumed Lake Okeechobee would supply the supplemental irrigation water in the incremental simulations.

Seepage from North of Lake Okeechobee Storage

The design of the North of Lake Okeechobee Storage in the Restudy did not include seepage from the reservoir back to Lake Okeechobee. The *LEC Regional Water Supply Plan* assumed a fifty percent seepage return to the lake. This assumption will need to be reevaluated as more information about the geology of the area and design of the reservoir becomes available.

St Lucie Reservoir Modifications

The Indian River Lagoon Feasibility Study recently completed an investigation to optimize the C-44 Reservoir. St Lucie Estuary target, local basin runoff, reservoir size, and operations were modified (**Table 11**). The C-44 reservoir size was reduced to 30,000 acres while the depth has increased to 10 feet. The revised design and operation were incorporated into all LEC model simulations when appropriate.

Table 11. Revised Performance Targets for the St Lucie Estuary.

Flow Range	Desired Maximum Number of Months in Range
< 350 cfs - monthly	178
> 2,000 cfs - monthly	23
> 3,000 cfs - monthly	5
> 2,000 cfs – 14 day average	23

ANALYSIS OVERVIEW

In order to determine the effects of existing and proposed water management facilities on water resources and the environment and the ability to meet projected water demands, base simulations were performed with both the SFWMM and the subregional ground water models.

The first set of simulations represented current (1995) conditions under historic 1995 demands. The second set represented future (2020) demands under identical rainfall conditions with Restudy projects expected to be completed by 2020 in place. This includes the Everglades Construction Project, Lake Okeechobee WSE Schedule, Modified Water Deliveries for Everglades National Park, the C-111 Basin Project, and portions of the *Lower East Coast (LEC) Interim Plan*. The third set of simulations, LEC 2020 with Restudy, included the construction projects and operational features of the Restudy that are expected to be in place by 2020. The fourth set, LEC-1, includes all features of the previous simulation plus additional features and operational changes that are specific to this plan, such as redistribution of wellfields, implementation of selected water supply development options, and refinements concerning implementation of the water resource development projects which are being made in the CERP. Areas that performed well were identified by applying the planning criteria and performance measure targets such as MFLs, 1-in-10 year level of certainty, and resource protection criteria.

Given the large number of criteria applied and the large number of areas evaluated in the LEC Planning Area, a simplified approach was used to display evaluations. The performance of a model simulation is summarized as green, yellow, or red for each evaluation criterion, based on ability to meet the criterion/target. The color provides an assessment of the ability of the plan to achieve the resource protection, recovery, and/or long-term sustainability objectives defined by the performance measure(s) and best professional judgement. Green means that the combination of features in the model simulation is likely to meet the management objective described by the performance measure. Yellow means that achievement of the objective is marginal or uncertain, and that improvement is needed or that the hydrologic target is not defined. Red means that the objective may not be met. The color coding scheme is similar to that used in the Restudy to assess the overall performance of the recommended components, compared to the no action alternative.

The Caloosahatchee Basin performance was analyzed in the *Caloosahatchee Water Management Plan* (*CWMP*) which can be found in the *CWMP*. Analysis of the results from these models form the basis of the *CWMP*'s recommendations. The recommendations made in the *CWMP* that are pertinent to the LEC planning process can be found in Chapter 6 of this plan.

URBAN AND AGRICULTURAL WATER SUPPLY RESULTS

This section presents and discusses the results of *LEC Regional Water Supply Plan* base cases, alternatives, and incremental evaluations with regard to urban and agricultural water supply. Results are first presented for the Lake Okeechobee Service Area (LOSA) and then for the LEC Service Area (North Palm Beach Service Area, LECSA 1, LECSA 2, and LECSA 3). For each service area the discussion of the results is followed by a summary. The service areas themselves are delineated and described in **Chapter 3**. The results are evaluated in terms of water supply performance goals, which have been described in **Chapters 2 and 4**. Descriptions of the key assumptions of the base cases, alternatives, and incremental simulations have been presented in the water and land use assumptions section of this chapter.

Lake Okeechobee Service Area

The Lake Okeechobee Service Area (LOSA) includes those areas for which Lake Okeechobee is the primary direct storage source. The major subbasins within LOSA include the EAA, the Caloosahatchee Basin (C-43 Basin), the St. Lucie Canal Basin (C-44 Basin), the Brighton Seminole Reservation, the Lower Lake Istokpoga Basin, and the Big Cypress Seminole Reservation. A map depicting LOSA can be found in **Chapter 3**.

In the LOSA, water supply evaluations were made using the SFWMM which performs simulations for the 31-year period from 1965 through 1995. For the purpose of water supply evaluations in this largely agricultural area, a water year (from October to September), rather than a calendar year, has been used. Thirty complete water years are covered by the simulation period.

Performance Measures Applied

The key water supply performance goal is that no more than three water years with significant water shortages occur during the simulation period. A water shortage is generally considered significant when greater than 100,000 acre-feet of demands are not met. This performance measure is obtained from the performance graphic tilted Frequency of Water Restrictions combined with analysis of the total volume of water restricted from the Supply-Side Management Report. During the simulations, a water shortage is recorded when the SFWMM recognizes that regional water storage conditions occur which meet the conditions under which the District will place LOSA under supply-side management restrictions. Supply-side management procedures and their application within the *LEC Regional Water Supply Plan* evaluations are more completely explained in Chapter 3.

If there are significant supply-side management cutbacks beyond three water restriction years, the goal of providing a 1-in-10 year level of certainty is not met. One way to look at the significance of these events is to consider the supply-side management cutback volumes for the fourth and fifth worst drought years in a simulation. This information is provided in the last row of the information tables in the results sections below. In considering the supply-side management volumes, it is important to remember that LOSA contains 600,000 to 700,000 acres of irrigated lands, so that 100,000 acre-feet of supply-side cutbacks implies a delivery deficit of about two inches spread over the irrigated lands in the service area over a 12-month crop year.

Base Cases and Alternatives Results

Information regarding the water supply performance under the base cases and alternatives is presented in **Table 12**. The first row in **Table 12** provides the number of water years with significant water shortage events while the second row provides the total number of water years in which any water shortage event occurs. The remaining information in **Table 12** further clarifies the significance of the water restrictions and the performance pattern that may be achieved through 2020.

1995 Base Case. Water restrictions occur for eight of the 31 years simulated in the 1995 Base Case and the total number of months of water shortages is 32. The supply-side management cutback volumes are high (over 300,000 acre-feet) for all of the three worst drought years. The supply-side management volumes in the fourth and fifth worst cutback years are 125,000 and 64,000 acre-feet, respectively. The 125,000 acre-feet of restrictions in 1990 indicate an inability to meet the 1-in-10 year level of certainty goal.

2020 Base Case. Water restrictions occur for 16 of the 31 years simulated in the 2020 Base Case and the total number of months of water shortages is 79. As with the 1995 Base Case, the supply-side management cutback volumes are high (over 300,000 acre-feet) for all of the three worst drought years. The supply-side management cutback volumes for the fourth and fifth worst years are close to 400,000 acre feet, which could easily lead to significant crop losses. In fact, cutbacks over 100,000 acre-feet occur in nine of the years.

Table 12. Information on All Water Restrictions in the SFWMM Simulations for the Base Cases and Alternatives for the Lake Okeechobee Service Area.

	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Number of water years with significant shortages	4	9	3	2
Number of water years with shortages in one or more months	8	16	5	5
Total months of water shortages	32	79	23	18
Total supply-side management cutback volume (acre-feet) for 31-year period	1,419,000	3,894,000	859,000	709,000
Supply-side management cutback volumes for the three worst drought years	1981 – 509,000 1974 – 355,000 1982 – 318,000	1974 – 491,000 1990 – 490,000 1981 – 435,000	1981 – 464,000 1982 – 212,000 1990 – 135,000	1981 – 381,000 1982 – 182,000 1990 – 81,000
Supply-side management cutback volumes for the fourth and fifth worst drought years	1990 – 125,000 1973 – 64,000	1982 – 396,000 1989 – 388,000	1974 – 20,000 1991 – 16,000	1976 – 30,000 1978 – 18,000

LEC 2020 with Restudy. The LEC 2020 with Restudy simulation has five years with water restrictions and the total number of months of water shortages for the LEC 2020 with Restudy is 23. The second and third worst years are significantly lower (212,000 and 135,000, respectively) for the LEC 2020 with Restudy than for the base cases. The fourth and fifth worst years show restrictions of only 2,000 acre-feet. The volumes of these cutbacks would not lead to significant crop losses. Based on the supply-side management cutbacks, the LEC 2020 with Restudy alternative meet the 1-in-10 year level of certainty goal for LOSA.

LEC-1. The LEC-1 simulation also has five years with water restrictions The total months of water shortages for the this simulation is 18, While the supply-side management cutback volumes are not as low as those for the LEC 2020 with Restudy, volumes are still significantly lower for the LEC-1 than for the base cases and would not lead to significant crop losses. Based on the supply-side management cutbacks, the LEC-1 alternative meets the 1-in-10 year level of certainty goal for LOSA. Supply-side management cutbacks are greater than 100,000 acre-feet and would be considered significant in only two of the years simulated. Based on the supply-side management cutbacks in LEC-1, it meets the 1-in-10 level of certainty goal in LOSA.

Incremental Results

Information regarding the water supply performance in the incremental simulations is presented in **Table 13.** The first row in **Table 13** provides the number of water years with significant water shortage events while the second row provides the number of water years in which any water shortage event occurs. The remaining information in **Table 13** further clarifies the significance of the water restrictions and the performance pattern that may be achieved through 2020.

Table 13. Information on Water Restrictions in the SFWMM Incremental Runs for the Lake Okeechobee Service Area.

	1995 Revised Base Case	2005	2005 SSM Scenario	2010	2015	LEC-1 Revised
Number of water years with significant shortages	5	7	5	6[a]	3	1
Number of water years with shortages in one or more months	9	11	7	9	6	4
Total months of shortages	37	47	35	36	21	12
Total SSM cutback volume (acre-feet) for 31-year period	1,878,000	2,571,000	1,693,000	1,496,000	860,000	432,000
SSM cutback volumes for three worst drought years	1982 – 461,000 1974 – 417,000 1981 – 339,000	1981 – 472,000 1974 – 463,000 1982 – 462,000	1982 – 445,000 1974 – 403,000 1981 – 312,000	1974 – 390,000 1981 – 379,000 1982 – 201,000	1981 – 305,000 1974 – 233,000 1976 – 145,000	1981 – 294,000 1982 – 95,000 1990 – 31,000
SSM cutback volumes for fourth and fifth worst drought years	1973 – 228,000 1990 – 197,000	1973 – 351,000 1990 – 320,000	1973 – 213,000 1990 – 171,000	1976 – 148,000 1973 – 129,000	1982 – 102,000 1990 – 56,000	1978 – 5,000

a. Performance could be improved by continuing supply-side flexibility or other option applied to 2005 SSM Scenario through 2010.

1995 Revised Base Case. The number of water years with water restrictions for the 1995 Revised Base Case simulations is nine and the total number of months of water shortages is 37. This is worse than the original 1995 Base Case due primarily to the inclusion of revised Caloosahatchee hydrology and agricultural demands and the inclusion of the Seminole Big Cypress Basin demands in the revised evaluation. The supply-side cutback volumes are high (over 300,000 acre-feet) for all of the three worst drought years in the 1995 Revised Base simulation. The supply-side management cutback volumes for the fourth and fifth worst years are 228,000 and 197,000 acre-feet, which represent a significant delivery deficit.

2005. The total number of years with water shortages (11) and total number of months of water shortages (47) increases in the 2005 incremental simulation. The supply-side cutback volumes are over 400,000 acre-feet for all of the three worst drought years and the fourth and fifth worst drought years still have significant shortages with supply-side management cutback volumes over 300,000 acre-feet. The increase in shortages between 1995 and 2005 can be attributed to a number of factors: 1) the implementation of the Everglades Construction Project in combination with the Lake Okeechobee WSE regulation schedule allows more lake water to be transferred to the WCAs, which results in a lower lake level going into some drought years; 2) the incorporation of a rainfall driven schedule for the WCAs and Everglades National Park results in more urban area demand being satisfied by Lake Okeechobee and less reliance on the WCAs for urban water supply; 3) an increase in agricultural demand in the Lake Istokpoga Service Area is satisfied by Lake Okeechobee in order to achieve environmental objectives in Lake Istokpoga; and 4) an increase in agricultural demand in the Caloosahatchee Basin due to land being taken out of production for the ECP. These additional demands are expected prior to completion of any significant storage features recommended by the Restudy.

2005 SSM Scenario. With the operational flexibility of the supply-side management criteria, the total number of years with shortages is reduced to seven in the 2005 SSM Scenario. The total number of months of water shortages (35) is also reduced in this simulation. Two of the worst shortages in the 2005 SSM Scenario are over 400,000 acre-feet and the third is just over 300,000 acre-feet. This performance is better than the original 2005 incremental simulation and the 1995 Revised Base Case. The volumes of cutbacks are 213,000 and 171,00 acre-feet for the fourth and fifth worst droughts, respectively, which represents an improvement over the volume of cutbacks in the 1995 Revised Base Case. Modification of the supply-side management criteria, or an equivalent operational schedule change, would improve upon the 1-in-10 year level of certainty in LOSA.

2010. The total number of years with shortages in the 2010 incremental simulation was nine. and the total number of months of water shortages is 36. In this simulation the volume of cutbacks is significantly less than that of the 1995 Revised Base, even though the years and months of shortages are about the same. For the 2010 incremental simulation, the worst two years have close to 400,000 acre feet of supply-side shortages while the third worst year has significantly less cutbacks at 201,000 acre-feet. The cutbacks for the fourth and fifth worst drought years are 148,000 and 129,000 acre-feet, respectively, which are substantially less than the previous simulations. This is the first sign that Restudy infrastructure is making water supply conditions better than the 1995 Revised Base Case. The 2010 performance could be improved by implementing an interim operational change such as modification of the supply-side management criteria.

2015. The total number of years with shortages (six) and the total number of months of water shortages (21) for the 2015 incremental simulation are reduced when compared to previous simulations. The improvement in supply-side cutback volumes which began in the 2010 simulation continues in the 2015 simulation, for which the third worst supply-side management event shows only 145,000 acre-feet of supply-side management cutbacks. The fourth and fifth worst years have supply-side management cutbacks of 102,000 and 56,000 acre-feet, respectively, and it is unlikely that they would cause significant reductions in crop yields. The level of performance in 2015 simulation indicates that the 1-in-10 level of certainty.

LEC-1 Revised. The LEC-1 Revised simulation's performance improves when compared to the original LEC-1 simulation. The chief reasons for this appear to be the changed configuration and operations of the EAA reservoirs, capture and storage of runoff from the Hillsboro Basin, and use of water from the C-51 and West Palm Beach ASR systems to meet demands in the EAA. The total number of months of water shortages and the volumes of cutbacks are reduced when compared to previous incremental simulations. The third worst supply-side management event has only 31,000 acre-feet of cutbacks and the fourth worst year of cutbacks is only 5,000 acre-feet, which is clearly insignificant. The results indicate that the LEC-1 Revised alternatives has the ability to meet the 1-in-10 level of certainty.

Summary of Results for the Lake Okeechobee Service Area

- The poor water supply performance of the 1995 and 2020 base cases indicates that significant water resource development efforts will be needed to achieve a 1-in-10 year level of certainty to water users in LOSA.
- The LEC 2020 with Restudy, LEC-1, and LEC-1 Revised model simulations, which contain the projects recommended in the Restudy as their primary water resource development components, are capable of meeting 1-in-10 year level of certainty performance within LOSA.
- The incremental simulations indicate improvements to the ability to meet LOSA's demands are possible as Restudy projects are implemented and performance improves between 1995 and 2020.
- The incremental simulations indicate that water supply performance can be met by 2015 in LOSA.
- The incremental simulations indicate that optimization in the design and operation of the Restudy projects can significantly improve the performance that was originally estimated in the *Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for the Central and Southern Florida Project Comprehensive Review Study* (USACE and SFWMD, 1999). These refinements to the Restudy projects will be included in the recommendations to the Comprehensive Everglades Restoration Plan (CERP).
- Actions such as CERP acceleration, changes to supply-side management criteria, or other operational improvements are needed to reduce the risk of water shortage losses in the interim period. The 2005 SSM Scenario demonstrated the flexibility in the application of supply-side management as one tool to meet water demands during droughts in the interim period until water resource development projects are completed. Other operational options should also be investigated.

Lower East Coast Service Areas

The Lower East Coast Service Area (LECSA) includes coastal areas east of the Everglades. For planning purposes the area has been divided into four service areas, each of which encompasses a number of coastal canal basins. These areas are the Northern Palm Beach County Service Area, LEC Service Area 1 (LECSA 1), LEC Service Area 2 (LECSA 2), and LEC Service Area 3 (LECSA 3). The service areas generally reflect the historical sources of water delivered from the regional system. LECSA 1 includes coastal basins, which receive water from WCA-1. Likewise LECSA 2 and LECSA 3 include coastal basins which receive water from WCA-2 and WCA-3, respectively. The Northern Palm Beach Service Area has historically received water from Lake Okeechobee via the

L-8 and the M canals. More complete descriptions of these areas and figures showing their extent are provided in **Chapter 3**.

Two situations will cause declarations of water shortages to be simulated in the LECSA. The first situation occurs when supply-side management is imposed in the LOSA for longer than seven days. This indicates that water from regional storage might not be available and cutbacks in usage and deliveries at this time may be needed to save water for more crucial times later in the dry season. The other situation occurs when ground water levels at coastal saltwater intrusion monitoring locations indicate that water restrictions are necessary to minimize saltwater intrusion. Note that the SFWMM can only provide generalized indications regarding water levels at coastal saltwater intrusion monitoring locations because of the large (two mile by two mile) grid size used in this model. Because of this limitation performance in the coastal ground water monitoring locations is also analyzed in the subregional ground water models. The incremental simulations do not include results from the subregional ground water models for the LEC Service Area and therefore the incremental analysis should be considered preliminary and are not indicative of future performance.

South Florida Water Management Model Base Cases and Alternatives Results

The number of years with water restrictions within the LECSAs caused by Lake Okeechobee supply-side management during the 31-year simulation period were five for the 1995 Base Case, 11 for the 2020 Base Case, three for the 2020 with Restudy Alternative, and two for the LEC-1 Alternative. These data are presented together for the entire service area since any shortage declarations apply equally to all of the coastal basins. The number of such shortages for the 1995 Base Case and 2020 Base Case are excessive and indicate the inadequacy of regional storage in the absence of major water resource development projects. The number of years of water shortages for the 2020 with Restudy and LEC-1 simulations indicate that the components recommended by the Restudy can provide a 1-in-10 year level of certainty for the LECSA.

The information in **Table 14** summarizes the modeled frequency of water shortage declarations due to coastal saltwater intrusion water level criteria. These data are presented for each subarea within the service area since water shortage declarations are usually by subarea based on local resource conditions.

Table 14. Number of Years with Water Restrictions Caused by Local Triggers in the Base Cases and Alternatives SFWMM Simulations for Lower East Coast Service Areas during the 30 Water Years Simulated.

Service Area	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Northern Palm Beach County	5	0	0	0
Service Area 1	7	8	0	0
Service Area 2	21	23	2	12
Service Area 3	3	3	2	2

Table 15 presents tabulations of the number of times water shortages are triggered by local ground water conditions by trigger well locations. Results indicate that amounts and locations of withdrawals significantly affect coastal saltwater intrusion problems. Both SFWMM and subregional ground water model results must be analyzed to determine if a 1-in-10 year level of certainty is met. The subregional ground water results are discussed later in this section, following the SFWMM discussion.

1995 Base Case. Water shortage problems are significant in the 1995 Base Case in all service areas except LECSA 3, where regional wellfields have been established inland from areas subject to saltwater intrusion. Ground water level monitoring locations in the Tequesta, Jupiter, Lake Worth, Fort Lauderdale Airport, Hollywood, and Homestead areas account for most of the shortages. A 1-in-10 year level of certainty performance is not met in this simulation.

Table 15. Number of Times Water Restriction Triggers in the SFWMM Base Case and Alternatives for the Lower East Coast Service Area Were Triggered.[a]

Trigger Well	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1	LEC-1A
Tequesta	5				
Jupiter	4				
Gardens					
Lake Worth	11	13			
Pompano	1				
North Lauderdale	3	3	3	3	
Lauderdale	4	19 + (4)			
FTL Airport	27 + (1)	31 + (2)	1	2	
Hollywood	54 + (2)	61 + (6)	4	17	
North Miami Beach	1	1			
Miami		1			
Cutler Ridge	1	6			
Homestead	5	5			
Florida City	2	3			
Taylor	3	4	5	5	5

a. Phase 2 in parentheses, all others are Phase 1

2020 Base Case. In the 2020 Base Case, which uses the utility preferred locations for future withdrawals, water shortages caused by local triggers are significant only in LECSA 1 and LECSA 2. Ground water level monitoring trigger events in the North Palm Beach Service Area have been eliminated, most likely due to assuming a recharge canal and increased use of Floridan aquifer water. Lake Worth, Fort Lauderdale Airport, and Hollywood areas continue to indicate low ground water levels. Lauderdale and Cutler Ridge are locations where trigger events increase compared to the 1995 Base Case. A 1-in-10 year level of certainty performance is not met in this simulation.

LEC 2020 with Restudy. In the LEC 2020 with Restudy model simulation, not only is the Restudy infrastructure through 2020 modeled as having been completed, but significant PWS demands are redistributed within the service area as well. Eastern wellfields at Miramar, Hollywood, Broward County 3A/3B/3C, Dania, and Hallandale are assumed on standby with their entire demand met from western facilities. The following utilities have a portion of their demands shifted inland: Riviera, Lake Worth, Manalapan, Lantana, Boca Raton, and Florida City. These assumptions are consistent with the Restudy's recommendations. Based on coastal ground water levels, North Palm Beach Service Area, LECSA 1, LECSA 2, and LECSA 3 meet the 1-in-10 year level of certainty. Model results indicate that no ground water level triggering occurs in the North Palm Beach Service Area or LECSA 1 (**Table 14**). In LECSA 3, the two years of locally triggered water shortages can be discounted because they are caused exclusively by the Taylor monitoring location which triggers even when public water supply withdrawals are eliminated (LEC-1A- no public water supply). There are two remaining years with cutback events in LECSA 2. They are caused by coastal ground water level monitoring locations in the Hollywood, North Lauderdale, and Fort Lauderdale Airport Areas. They occur during 1971 and 1975 and not during the 1-in-10 drought year identified and used for the ground water model simulations discussed below. The LEC 2020 with Restudy simulation solved the low ground water level in this area seen in the 2020 Base Case by placing the coastal wellfields in Southeast Broward County on standby.

LEC-1. In the LEC-1 model simulation, not only is the Restudy infrastructure through 2020 modeled as complete, but different wellfield withdrawals and distributions are modeled compared to the 2020 with Restudy. In the LEC-1 model simulation, North Palm Beach Service Area, LECSA 1, and LECSA 3 meet the 1-in-10 year level of certainty based on coastal ground water conditions. The LEC-1 model results indicate that no ground water level triggering occurs in the North Palm Beach Service Area or LECSA 1. In LECSA 3, only the same nonwithdrawal related triggers occur at Taylor. However, twelve years of coastal saltwater intrusion triggers occur in LECSA 2 (**Table 4-11**). They primarily occur at the coastal ground water level monitoring location in the Hollywood area. A few triggers also occur in the North Lauderdale and Fort Lauderdale Airport areas (**Table 15**). In this case, restrictions do occur during the 1-in-10 rainfall deficit year identified and used for the subregional ground water model simulations discussed below. Because the utility preferred locations for withdrawals are the basis for the LEC-1 simulations, a greater volume of public water supply withdrawals remain at the current locations along the coast near the saline interface than in the 2020 with Restudy simulation especially in southeast Broward County. The model results indicate that the potential for saltwater intrusion due to public water supply withdrawals is high and this area is very sensitive to public water supply withdrawal amounts and locations simulated in LEC-1. The utility preferred locations as modified in LEC-1 indicate that a smaller volume of withdrawals may need to be moved away from the coast than simulated in the LEC 2020 with Restudy simulation. The higher number of water restrictions in LEC-1 in the Hollywood area could be reduced to meet a 1-in-10 level of certainty as seen in the LEC 2020 with Restudy simulation. Model iterations with different wellfield distributions would demonstrate this.

The SFWMM simulations indicate that with the planned water resource development projects and appropriate water supply development (in the form of locations of demands that meet existing permit criteria), water shortages will occur only about one year in ten. It is important, however to look at the ability to meet demands during a 1-in-10 year rainfall deficit event with the high resolution ground water models. This is the focus of evaluation of subregional ground water model results.

Subregional Ground Water Model Base Case and Alternatives

The number of years with water restrictions within the LECSAs caused by Lake Okeechobee supply-side management during the 31-year simulation period were five for the 1995 Base Case, 11 for the 2020 Base Case, three for the 2020 with Restudy Alternative, and two for the LEC-1 Alternative. These data are presented together for the entire service area since any shortage declarations apply equally to all of the coastal basins. The number of such shortages for the 1995 Base Case and 2020 Base Case are excessive and indicate the inadequacy of regional storage in the absence of major water resource development projects. The number of years of water shortages for the 2020 with Restudy and LEC-1 simulations indicate that the components recommended by the Restudy can provide a 1-in-10 year level of certainty for the LECSA.

The five subregional ground water models used in the *LEC Regional Water Supply Plan* are used to evaluate the ability to meet a 1-in-10 year level of certainty in the LECSA. They provide a more detailed look at water conditions compared to the SFWMM, because of their fine grid cell size, generally 500 feet by 500 feet, compared to the two mile by two mile cell for the SFWMM. Because of the detail involved in simulations of these models, they are the primary tool for evaluating performance during a historic period that closely matches a 1-in-10 year rainfall deficit event. This detail allows performance to be evaluated in terms of three water resource conditions during the 1-in-10 year rainfall event.

1. The triggering of water shortages is evaluated based on water levels at selected monitoring locations. This measure parallels the water shortage triggering evaluated in the SFWMM but provides much more location specificity because of the fine grid cell size.
2. Potential movement of the saltwater interface is evaluated by considering the net westward flow across the present location of the saltwater interface for the year that represents the 1-in-10 year rainfall deficit condition.
3. Potential impacts on wetlands are evaluated by considering ground water level drawdown events of one foot or more under identified wetland areas. An event occurs when the 30-day average head differs between the simulation and the no consumptive use withdrawals simulation more than or equal to one foot.

Despite the detail of the ground water models the model results are not predictive. They are not necessarily representative of actual local conditions, either now or in the future. Thus, failure to identify problems in the model simulations in this plan does not ensure issuance, reissuance or modification of water use permits, nor does the indication that there is not a problem preclude the same.

Results of the evaluations of the ground water model results for the 2020 with Restudy and LEC-1 Alternatives with respect to the three performance areas are presented in **Table 16.** The 1-in-10 year level of certainty can be met in the 2020 with Restudy and LEC-1. A summary of water restrictions due to coastal ground water levels in all of the base cases and alternatives from the ground water models is presented in **Table 17**. In most areas, the coastal water shortage triggers do not trigger a water restriction during 1-in-10 year rainfall deficit event. In the isolated cases where model results indicate problems, changing withdrawal locations or other operations enable the water shortage criteria for coastal ground water levels to be met. These isolated events are discussed below.

- Results for the LEC-1 simulation indicate that low ground water levels at PB-632 in the Riviera Beach Area, which are evidenced in the LEC 2020 simulation, can be avoided by shifting public water supply withdrawals to Riviera Beach's proposed wellfields located farther west, but within the constraints of the landfill.
- The restrictions associated with the PB-809 trigger in the Clear Lake area in the 2020 with Restudy simulation appear to result from the assumption that ASR wells in the area would be injecting during dry periods. An appropriate response would be to stop injecting during this period in the model simulation and so this was incorporated into LEC-1.
- In the Fort Lauderdale Airport area (LECSA 1), the trigger well is sensitive to wellfield withdrawal distributions. The LEC 2020 with Restudy simulation does not trigger shortages in this area, but the LEC-1 simulation does. A slight change in distribution within Dixie wellfield would prevent these low ground water levels and resulting restrictions in LEC-1. It is important to note that, while there are no restrictions in the Hollywood area in LEC-1, the location of the trigger well, east of the C-10 Canal, may preclude it from accurately assessing saltwater intrusion effects of the Hollywood withdrawal. The aquifer recharge provided by the Broward County Secondary Canal System from the C-9 creates a mound that effectively protects the trigger cell (F-219) from effects of withdrawals in the Hollywood’s south wellfield. The effectiveness of the recharge facility, timing of construction, and PWS demands need to be assessed during the Consumptive Use Permitting (CUP) process.

Table 16. Water Supply Results for Ground Water Model Simulations of the LEC 2020 with Restudy and the LEC-1 Alternatives[a]

LEC Service Area	Water Restriction Area	Coastal Water Shortage Triggers During LEC 1-in-10 Year Rainfall Conditions	Net Westward Ground Water Flow at the Saltwater Interface During LEC 1-in-10 Year Rainfall Conditions	Impacts on Isolated Wetlands During LEC 1-in-10 Year Rainfall Conditions
North PB County	Jupiter	No indicated problems	Tequesta: Locally, west flows intersects the interface. Probably related in part to individual well withdrawal distribution and model cell size.	Seacoast, Jupiter and Riviera Beach: Numerous wetlands affected by drawdown events. Need to verify location and condition of wetlands inside one-foot drawdown.
	Clear Lake	Riviera Beach: Results for PB-632 trigger well appear to be very sensitive to how much pumpage is east of C-17. LEC-1 has limited pumpage to the east and shows no triggering. 2020 with Restudy has all withdrawals east of C-17 and triggers Phase 2 shortages. Results for PB-809 show some triggering in LEC-1 associated with operations of ASR wells during dry periods. This problem does not appear in the 2020 with Restudy run.	Riviera Beach: Westward ground water flows intersect the interface in both LEC-1 and 2020 with Restudy.	No indicated problems
	Palm Beach Gardens	No indicated problems	No indicated problems	No indicated problems
LEC Service Area 1	Lake Worth	No indicated problems	No indicated problems	Lake Osborne ASR wells show wetlands affected by drawdown events. Some wetlands are connected to and controlled by the lake, others are not.
	Royal Palm Beach Wellington	No indicated problems	No indicated problems	No indicated problems
	Delray Beach	No indicated problems	No indicated problems	Palm Beach County Utilities and Delray Beach: Few scattered wetlands affected by drawdown events from wellfields along and east of Turnpike. The location and condition of wetlands need to be verified.
	Boca Raton	No indicated problems	Boca East Wellfield: Westward flow at the interface.	No indicated problems
	Boca Raton West	No indicated problems	No indicated problems	Boca West Wellfield: Wetland to the east affected by drawdown events. Configuration suggests this may be excavated and not natural wetland.

Table 16. Water Supply Results for Ground Water Model Simulations of the LEC 2020 with Restudy and the LEC-1 Alternatives[a]

LEC Service Area	Water Restriction Area	Coastal Water Shortage Triggers During LEC 1-in-10 Year Rainfall Conditions	Net Westward Ground Water Flow at the Saltwater Interface During LEC 1-in-10 Year Rainfall Conditions	Impacts on Isolated Wetlands During LEC 1-in-10 Year Rainfall Conditions
LEC Service Area 2	Pompano Beach	No indicated problems	Pompano: West flow across the interface in LEC-1 and 2020 with Restudy.	Pompano east wellfield: A wetland east of the wellfield is affected by drawdown events. Need to verify location and condition of wetland.
	Fort Laud Airport	Potential saltwater intrusion problems triggers are sensitive to location of withdrawals. Geographic distribution of wellfield withdrawals in 2020 w/Restudy does not trigger shortages, while the distribution in LEC-1 does.	Dixie: Slight west flow across the interface in LEC-1.	Fort Lauderdale Airport wellfield: A wetland southeast of wellfield is affected by drawdown events and should be verified.
	Hollywood	No indicated problem, but the trigger well is east of C-10 and may not reflect problems caused by withdrawals at Hollywood's wellfields in LEC-1.	Hollywood: Westward flow across the interface in LEC-1.	No indicated problems
	Western Broward County	No indicated problems	No indicated problems	Sunrise: Wetlands near Broward County South Regional Wellfield and Miramar are affected by drawdown events. Size and shape of wetlands suggest excavations, not natural. City of Coral Springs and North Springs Improvement District: Scattered wetland affected by drawdown events. Coral Springs Improvement District: wetlands at the edge of the 1-foot contour.
LEC Service Area 3	North Miami Beach	No indicated problems	North Miami: Westward flow across interface in LEC-1 and 2020 with Restudy, based on 4.45 MGD with balance of demands from WASD Northwest wellfield in LEC-1. North Miami Beach: OK at 15 MGD with balance of demands from WASD Northwest wellfield in LEC-1.	No indicated problems
	Miami	No indicated problems	Hialeah-Preston: Westward flow across the interface which may be due to surface drainage features.	Northwest wellfield: extensive wetlands affected by drawdown events in the area are likely to have been mitigated under existing permit.
	Kendall	No indicated problems	No indicated problems	No indicated problems
	Kendall Lakes	No indicated problems	No indicated problems	No indicated problems
	Homestead	No indicated problems	Rex-Homestead area: Significant westward flow across interface in 2020 with Restudy.	West wellfield: Wetlands affected by drawdown events in Bird Drive mitigation areas.

a. This table generally summarizes conditions observed in ground water models of the Lower East Coast. Model results are predictive, and are regional and generalized in nature and not necessarily representative of actual local conditions, either now or in the future. Please note that a determination of no problems from a model run does not ensure issuance, reissuance, or modification of water use permits, nor does determination of a problem preclude it.

Table 17. The Number of Days each Water Restriction Area is Cutback in the LEC Service Area due to Local Ground Water Conditions.

LEC Service Area	Water Restriction Area	Subregional Ground Water Model Simulation			
		1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
North Palm Beach Service Area	Jupiter	127	0	112	0
North Palm Beach Service Area	Palm Beach Gardens	0	0	112	0
North Palm Beach Service Area	Clear Lake	0	0	75	19
LECSA 1	Royal Palm	0	0	112	0
LECSA 1	Wellington	0	0	0	0
LECSA 1	Lake Worth	0	114	0	0
LECSA 1	Delray Beach	0	0	0	0
LECSA 1	Boca Raton	0	0	0	0
LECSA 1	Boca West	0	0	14	0
LECSA 2	Western Broward	0	0	0	0
LECSA 2	Pompano	0	0	0	0
LECSA 2	Ft Lauderdale Airport	157	188	0	42
LECSA 2	Hollywood	194	192	0	0
LECSA 3	Kendall Lakes	0	0	0	0
LECSA 3	Miami	0	0	0	0
LECSA 3	N Miami Beach	0	0	0	0
LECSA 3	Kendall	0	0	0	0
LECSA 3	Homestead	0	0	0	0

- The majority of the wellfields in LECSA 3 are centralized inland in Miami-Dade County, which enables avoidance of the water restrictions due to low ground water levels along the coast.

Generally, the PWS distribution in the LEC 2020 with Restudy simulation does not preform well due to the wellfield distribution assumed. In the LEC-1 simulation, which is based on the utility preferred withdrawal locations and sources, water supply demands are able to be met.

Indications of net westward ground water flows at the saltwater interface are noted in about half of the water restriction areas under the 1-in-10 year rainfall deficit conditions. In several cases, the westward ground water flow across the saltwater interface occurs in one alternative and not the other. This is indicative that redistribution of wellfield withdrawals is one method by which potential problems can be avoided. Refer to **Appendix H** for the performance measures graphics.Also, indications of drawdowns greater than one foot for more than 30 days beneath wetlands occur in about half of the water restriction areas under the 1-in-10 year rainfall deficit conditions. In many instances, the existence and nature of the mapped wetland areas needs to be verified. Also, sometimes the impacts shown are known and have been dealt with in previous permitting processes through avoidance and mitigation. For the most part, these results imply that more detailed evaluation will be necessary during any permit application process that involves pubic water supply amounts and distributions similar to those evaluated in these simulations.

South Florida Water Management Model Incremental Simulations Results

The number of years with water restrictions caused by Lake Okeechobee supply-side management is five for both the 1995 Revised Base and 2005 incremental simulations. The number decreases to three for the 2010 incremental simulation and then to two for both the 2015 and LEC-1 Revised simulations. Results for the 1995 Revised Base and 2005 incremental simulations indicate that they cannot meet a 1-in-10 year level of certainty due to Lake Okeechobee stages. This indicates the inadequacy of regional storage in the absence of major water resource development projects, which will not be completed until after 2005. The results for the 2015 Incremental and LEC-1 Revised simulations indicate that the projects recommended by the Restudy will provide a 1-in-10 year level of certainty for both the LECSA, as well as for the LOSA. In the 2005 SSM Scenario, the performance remains the same as the original 2005 incremental simulation. Changes to the supply-side management criteria did not affect the ability to provide regional water to the LECSA during a 1-in-10 year rainfall deficit event.

The information in **Table 18** summarizes the frequency of water shortage declarations due to coastal saltwater intrusion water level criteria. These data are presented for each service area since water shortage declarations are usually by service area based on resource conditions. **Table 19** presents tabulations of the number of times water shortages are triggered by local ground water conditions by trigger well locations. Results indicate that amounts and locations of pumpage significantly affect coastal saltwater intrusion problems and that such problems can be solved as soon as the appropriate wellfield distribution changes or water supply development options are implemented.

Table 18. Number of Years with Water Restrictions Caused by Local Triggers in the SFWMM Incremental Runs for Lower East Coast Service Areas during the 30 Water Years Simulated.

Service Area	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
North Palm Beach County	5	1	0	0	0
Service Area 1	7	0	0	0	0
Service Area 2	21	13	8	11	12
Service Area 3	4	5	3	3	2

1995 Revised Base Case. Water shortage problems are significant in the 1995 Revised Base in all service areas except LECSA 3, where regional wellfields have been established inland from areas subject to saltwater intrusion (**Table 19**). Ground water stage monitoring locations in the Tequesta, Jupiter, Lake Worth, Fort Lauderdale Airport,

Table 19. Number of times Water Restriction Triggers in the SFWMM Incremental Runs for Lower East Coast Service Areas Were Triggered.[a]

Trigger Well	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Tequesta	5				
Jupiter	4	1			
Gardens		1			
Lake Worth	11				
Pompano	1				
North Lauderdale	3	5	2	2	3
Lauderdale	4	1			
FTL Airport	27 + (1)*	25 + (1)	1	1	1
Hollywood	53 + (3)	21	12	15	17
North Miami Beach	1				
Miami		2			
Cutler Ridge	1	4			
Homestead	5	7	3	3	
Florida City	3	2			
Taylor	3	5	5	5	5

a. Phase 2 in parentheses, all others are Phase 1

Hollywood, and Homestead areas account for most of the shortages. This simulation does not meet the 1-in-10 year level of certainty.

2005. In the 2005 incremental simulation and subsequent incremental simulations, the utility preferred wellfield distribution as modified in LEC-1 is applied. In the 2005 incremental simulation, water shortages caused by local triggers are eliminated in LECSA 1 and greatly reduced in the North Palm Beach Service Area. The number of cutbacks in LECSA 2 is primarily a result of the sensitivity to the assumed location of public water supply withdrawals from the Surficial Aquifer System (SAS). The number of restrictions in LECSA 3 increases slightly when compared to 1995 Revised Base Case. This may be due to demand growth, changes in pumpage distribution from the 1995 Base Case, or other factors that affect water levels in areas near the Miami and Cutler Ridge monitoring locations.

2010. The 2010 incremental simulation indicates that the 1-in-10 year level of certainty can be met by 2010 based on coastal ground water conditions. There were no cutbacks due to low ground water levels in the North Palm Beach Service Area or LECSA 1. In LECSA 2, the number of restrictions occurring in the Fort Lauderdale Airport and Hollywood area decline from 2005, probably due to inclusion of the of the southern portion of the CERP’s Broward Secondary Canal Recharge System. In LECSA 3, triggers in the North Miami Beach, Miami, Cutler Ridge, and Florida City areas are eliminated while those in the Homestead area are further reduced. These improvements are likely due to implementation of features recommended in the Restudy and the additional Miami-Dade County Utility ASR.

2015. The 2015 incremental simulation continues to indicate no ground water level triggering in the North Palm Beach Service Area or LECSA 1. In LECSA 2 some additional triggering occurs in the Hollywood area, probably as a result of demand growth in the Hollywood area without any infrastructure or wellfield location improvements beyond 2010. The demand for Hollywood increases slightly from 19.31 MGD in 1995 to 22 MGD in LEC-1 Revised, while Hallandale, Dania Beach, and Broward 3A are on standby starting in 2005 and withdrawal is relocated to the Broward County South Regional wellfield. In LECSA 3, triggers in the Homestead area remain the same as in 2010.

LEC-1 Revised. The LEC-1 Revised simulation indicates that there are no water shortages due to low ground water levels in the North Palm Beach Service Area or LECSA 1. In LECSA 2, some additional trigger events occur in the Hollywood area and one additional trigger event occur in the Lauderdale area compared to 2015. These are also the likely result of demand growth without any additional infrastructure or wellfield location improvements beyond 2010 refinement of the wellfield distribution. In LECSA 3, trigger events in the Homestead area are eliminated and only those in the Taylor area that are insensitive to public water supply withdrawals remain.

The incremental simulation results indicate that the 1-in-10 year level of certainty improves over time as the Restudy and other water resource development projects are implemented. The volume and location of public water supply withdrawals significantly affect coastal saltwater intrusion. Saltwater intrusion can largely be avoided, and the associated restrictions diminished, as soon as the appropriate water supply options such as wellfield relocation, distribution, and operational changes are implemented. In 2005, water resource development and the utility preferred wellfield distribution (same as LEC-1) is followed. This solves coastal trigger problems in the North Palm Beach Service Area, LECSA 1, and LECSA 3. The low coastal ground water stages in LECSA 2 can be avoided by altering the distribution or allocation of public water supplies year round or conditionally, depending on the severity and location of low ground water stages. The LEC-1 Revised simulation demonstrated the ability to avoid salt-water intrusion and water restrictions with minor adjustments to public water supply distribution is possible.

Summary of Results for Lower East Coast Service Area

- The 1995 and 2020 base cases do not meet a 1-in-10 year level of certainty performance.
- The LEC 2020 with Restudy, LEC-1 and LEC-1 Revised model simulations have been shown to be capable of meeting 2020 water supply projections in the LEC Service Area.
- The SFWMM results demonstrate that The frequency of supply-side management restrictions in the 2020 with Restudy, the LEC-1, and the LEC-1 Revised meets the 1-in-10 year level of certainty planning criteria in the LEC Service Area.
- The redistribution of wellfield withdrawals in the LEC 2020 with Restudy and the LEC-1 simulations demonstrate the significant

effect wellfield withdrawals have on local ground water conditions and the ability to meet the 1-in-10 year level of certainty. This is evidenced in southeast and central Broward County where redistribution of wellfield withdrawals in the model simulations is the determining factor for meeting the 1-in-10 year level of certainty based on local conditions.

- Based on evaluations using the subregional ground water models, a 1-in-10 year level of certainty for public water supply can be met in the LEC Service Area based on the ability to meet the water shortage restriction criteria and avoid harm to wetlands and the Biscayne aquifer with implementation of Restudy projects, refinement of utility preferred wellfield distributions and operations, and implementation of water supply development options.
- Assuming the utility preferred withdrawal locations are implemented as proposed, several public water suppliers may need to implement water supply development options and/or refine their preferred wellfield locations in order to meet the 1-in-10 year level of certainty. These utilities include Lake Worth, Manalapan, Lantana, Fort Lauderdale, Hallandale, Hollywood, Dania Beach, and Broward County 3A, 3B, and 3C.
- A few utilities may meet a 1-in-10 year level of certainty, but may not meet CUP criteria for wetland drawdown and/or avoid salt water intrusion unless their wellfield distribution and seasonal operations are refined. These utilities include Seacoast, Jupiter, Riviera Beach, Pompano Beach, Boca Raton's eastern wellfield, Coral Springs, North Springs Improvement District, the proposed Miami-Dade Water and Sewer Department's (WASD's) proposed south regional wellfield and west wellfield, North Miami, North Miami Beach, and Homestead.

ENVIRONMENTAL RESOURCES RESULTS

As with the evaluations of urban areas, two different sets of simulations were performed using the SFWMM. The first set of simulations compares current base case (1995 Base Case) and future (2020 Base Case) conditions. A second set of model simulations was created to visualize the incremental changes that occur to the overall system in five-year intervals from 2005 to 2020. Detailed descriptions of the parameters, conditions, and rationales used in each model simulation can be found in the **Model Simulations** section of this Chapter. An overview of results for each set of simulations is presented first, then performance measures and results for both simulations are discussed by natural area.

District staff have recently developed proposed minimum water level criteria for three priority water bodies included within the LEC Planning Area (SFWMD, 2000e).

These water bodies include Lake Okeechobee, the Biscayne aquifer, and the Everglades. The Everglades includes the WCAs, the Holey Land and Rotenberger Wildlife Management Areas (WMAs), and the freshwater regions of Everglades National Park. The final draft document proposes minimum water level depths, duration, and frequencies of occurrence that will guide the operation of the C&SF Project and future management of Lake Okeechobee, the Everglades, and the Biscayne aquifer. These results are presented by natural area and model simulation.

Overview of Results

Overview of Base Cases and Alternatives Results

Results for the current base case and future (2020) scenarios were obtained from model simulations for the same conditions that were obtained for the urban areas: 1995 Base Case, 2020 Base Case, LEC 2020 with Restudy, and LEC-1. These conditions were analyzed and the results are displayed in formats similar to the methods that were used for the Restudy, with the addition of MFL criteria that were subsequently developed for Lake Okeechobee, the Everglades, and the Biscayne aquifer (SFWMD, 2000e).

Table 20 provides a color coded evaluation of the overall results of each base case and alternative simulation based on a review of key performance measures discussed later in this chapter and in Appendix D. The color codes (green, yellow, or red) represent a scoring system to evaluate model output based on review of key environmental performance measures listed in **Appendix D** of this report and use of best professional judgement by District scientists. A similar color code scheme and definitions was used in the Restudy to provide a qualitative assessment of the ability of particular water supply actions or features to meet environmental management objectives of this water supply plan.

1995 Base Case. A majority of the natural area (14 out of 21 areas evaluated) in the 1995 Base Case were scored as red, indicating they do not currently meet LEC environmental planning criteria (**Table 20**). These areas are Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, Lake Worth Lagoon, Rotenberger WMA, WCA-2B, northeast and northwest WCA-3A, WCA-3A East, central and southern WCA-3A, Shark River Slough, the Rockland marl marsh, and Western Florida and Whitewater bays. Ecosystem recovery will not occur in these areas unless major hydrologic improvements are made. Five areas scored yellow (**Table 20**), indicating marginal or uncertain ability to meet environmental targets and achieve recovery. These area are the Holey Land WMA, WCA-2A North (Indicator Region 25), central WCA-3A (Indicator Region 17), WCA-3B, and central and southern Biscayne Bay. Only three areas out of 21 scored green (**Table 20**), indicating that they currently meet environmental performance measure targets and will likely result in long-term sustainability of the ecosystem, providing water quality standards are met. These areas are the Loxahatchee National Wildlife Refuge (WCA-1), WCA-2A south, and northern Biscayne Bay.

Table 20. South Florida Water Management Model Results for Base Cases and Alternatives for Natural Areas within the Lower East Coast Planning Area.[a]

Area	Indicator Region(s)[b]	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Lake Okeechobee	NA	R	R	G	G
Caloosahatchee Estuary	NA	R	R	G	G
St. Lucie Estuary	NA	R	R	G	G
Lake Worth Lagoon	NA	R	Y	Y	Y
Holey Land WMA	29	Y	Y	G	G
Rotenberger WMA	28	R	G	G	G
Water Conservation Areas					
WCA-1 (LNWR)	26 and 27	G	Y	G	G
WCA-2A	24 and 25	Y/G	Y/G	Y/G	Y/G
WCA-2B	23	R	R	R	R
WCA-3A N.E.	21	R	Y	G	G
WCA-3A N.W.	20 and 22	R	G	G	G
WCA-3A East	19	R	Y	Y	Y
WCA-3A Central	17 and 18	R/Y	R/Y	Y/G	Y/G
WCA-3A South	14	R	R	G	G
WCA-3B	15 and 16	Y	Y	Y	Y
Everglades National Park					
Shark River Slough	9, 10, and 11	R	R	G/Y	G/Y
Rockland marl marsh	8	R	R	Y	Y
Western Florida and Whitewater Bays	NA	R	R	G	G
Northern Biscayne Bay	NA	G	Y	Y	Y
Central Biscayne Bay	NA	Y	Y	Y	Y

a. G (green) = planning targets met
Y (yellow) = ability to meet targets is marginal or uncertain, or goal is not defined
R (red) = planning targets not met

b. An indicator region is a grouping of model grid cells within the SFWMM that consists of similar vegetation cover and soil type. Indicator regions were used only in simulations for the Everglades.

2020 Base Case. Fewer areas scored red in the 2020 Base Case compared to the 1995 Base Case, but most of the region still did not meet the environmental planning targets (**Table 20**). The 2020 Base Case showed improvement in some areas over the 1995 Base Case. These areas are the Lake Worth Lagoon, the Rotenberger WMA, northern WCA-3A, and WCA-3 east (Indicator Region 19). Lake Worth Lagoon improved due to the capability to store water in STA-1 East, which reduced the amount of water discharged to the lagoon. The Rotenberger WMA and northern WCA-3A improved due to completion of the Everglades Construction Project in 2003. Two areas became worse under the 2020 Base Case, the Loxahatchee National Wildlife Refuge (WCA-1) and northern Biscayne Bay, changing from green to yellow.

LEC 2020 with Restudy and LEC-1. Results show that the 2020 with Restudy and LEC-1 simulations performed very similar to each other (**Table 20**) and provide significant hydrological improvements to the regional ecosystem. Significant and substantial progress is made in these alternatives in meeting environmental restoration targets for the Everglades and the estuaries. Overall, 14 out of 21 sites scored green under the LEC-1 and LEC 2020 with Restudy alternatives, indicating they meet LEC water supply planning targets and will likely result in recovery and long-term sustainability of the ecosystem, providing water quality standards are met. These areas are Lake Okeechobee, the St. Lucie and Caloosahatchee estuaries, the Holey Land and Rotenberger WMAs, Loxahatchee National Wildlife Refuge (WCA-1), northern WCA-2A, northeast and northwest WCA-3A, a portion of central WCA-3A (Indicator Region 17), southern WCA-3A, and western Florida and Whitewater bays. These alternatives show great improvement over the 1995 and 2020 base cases. Shark River Slough scored a green/ yellow, which was an improvement relative to the base cases, but did not perform quite as well as Alternative D13R in 2050 with all of the Restudy projects completed (USACE and SFWMD, 1999).

Areas that indicated marginal or uncertain ability to meet the environmental objectives of the *LEC Regional Water Supply Plan* (scored yellow) and need further improvement or where the target is not yet defined are the Lake Worth Lagoon, southern WCA-2A (Indicator Region 24), WCA-3A east (Indicator Region 19), a portion of central WCA-3A (Indicator Region 18), WCA-3B, the Rockland marl marsh located within Everglades National Park, and northern and central Biscayne Bay (**Table 20**). These results are very similar to those achieved under alternative D13R, with the Restudy projects completed by 2050.

Only one area, WCA-2B, scored red for the LEC 2020 with Restudy and LEC-1 alternatives (**Table 20**). These results indicate that environmental planning targets will not be met, ecosystem recovery will not likely occur, and WCA-2B will need major improvements. Again, these results are similar to results from the Restudy model simulations for this area. However, LEC-1 showed improved performance as compared to Alternative D13R (USACE and SFWMD, 1999).

Overview of Incremental Modeling Results

Table 20 provides a color-coded evaluation of the overall results of each incremental simulation based on a review of key performance measures discussed later in this chapter and in Appendix D. Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries show improvements by 2010, and meet their respective planning targets by 2015. These improvements are due in part to the construction of regional reservoirs within the C-43 and C-44 basins. Similar improvements occur over time in the Loxahatchee National Wildlife Refuge, northern WCA-3A, and the Holey Land and Rotenberger WMAs. These meet proposed planning targets by 2010 as a result of completion of the Everglades Construction Project and the EAA reservoirs, and implementation of rainfall-driven water deliveries for the WCAs. In contrast, performance measure targets are not met in central and southern WCA-3A and WCA-3B until 2020.

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Table 21. South Florida Water Management Model Results for Incremental Simulations for Natural Areas within the Lower East Coast Planning Area.

Area	Indicator Region	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised	D13[a]
Lake Okeechobee		R/Y	Y	Y	G	G	G
Caloosahatchee Estuary		R	R	Y	G	G	G
St. Lucie Estuary		R	R	Y	G	G	G
Lake Worth Lagoon		R	R	Y	Y	Y	Y
Holey Land WMA		R	R	G	G	G	G
Rotenberger WMA		R	Y	G	G	G	G
Water Conservation Areas							
Loxahatchee NWR	WCA-1	G	Y/G	G	G	G	G
WCA-2A (north/south)	25 and 24	Y/G	G/Y	G/Y	G/Y	G/Y	G/Y
WCA-2B	23	R	R	R	R	R	R
WCA-3A N.E.	21	R	G	G	G	G	Y
WCA-3A N.W.	22 and 20	R	Y	G	G	G	G
WCA-3A Eastern	19	R	Y	Y	Y	Y	Y
WCA-3A Central	18 and 17	R/Y	Y/G	Y/G	Y/G	Y/G	Y/G
WCA-3A South	14	R	Y	Y	Y	G	G
Everglades National Park							
Shark River Slough	9, 10, and 11	R	R	R/Y	Y	G/Y	G
Rockland marl marsh	8	R	Y	Y	Y	Y	Y
Western Florida /Whitewater Bay		R	Y	Y	Y	G	G
Northern Biscayne Bay		G	Y	G	G	Y	G
Central Biscayne Bay		Y	Y	Y	Y	Y	G
Southern Biscayne Bay		Y	Y	Y	Y	G	G

a. D13 was a simulation performed for the Restudy (USACE and SFWMD, 1999).

Incremental modeling results for Everglades National Park show a gradual improvement in attaining flow targets to the park. Beginning in 2005, the distribution and volume of water provided to northeast and northwest Shark River Slough significantly improves. By 2010 substantial improvements in meeting NSM hydroperiod targets were recorded within northeast and central Shark River Slough, with nearly full achievement of target by 2020 (100 percent of the slough matches the NSM hydroperiod target by 2020). In the Rockland marl marsh, significant hydroperiod were noted beginning in 2005 within this over-drained area of the park and improvements continue through 2020. These improvements appear to be linked to the completion of the Lake Belt Project (which is only 50 percent complete by 2020) and full implementation of Lake Okeechobee ASR, which frees up water that can be delivered downstream from the lake to Everglades National Park. These results show the importance of the Lake Belt Project, which serves as a large water storage reservoir in which water can be captured and stored during wet periods and delivered to Everglades National Park with the proper timing and volumes to hydrologically restore this area.

A number of areas did not fully meet the planning targets and were scored as yellow or red (**Table 21**). One area, WCA-2B, scored red in 2020 indicating that it did not meet planning targets and is in need of major improvement. Areas that scored yellow (exhibited marginal or uncertain performance) in 2020 included the Lake Worth Lagoon, WCA-3A east (Indicator Region 19), the southern portion of WCA-2A (Indictor Region 24), the Rockland marl marsh located within Everglades National Park, and northern and central Biscayne Bay. These results are similar to the findings presented by the Restudy, which identified problems in meeting proposed environmental targets for these areas by year 2050 (USACE and SFWMD, 1999).

Lake Okeechobee

Extreme fluctuations of both high and low water levels within Lake Okeechobee over the past two decades have had major adverse impacts on water quality, the distribution of littoral zone vegetation communities that support fish and wildlife habitat, and downstream estuaries which receive regulatory releases from the lake. The following set of performance measures were developed to judge how well each water supply alternative reduces the frequency of these extreme high and low water events and improves the overall performance of the regional ecosystem to meet the environmental objectives of the *LEC Regional Water Supply Plan*.

Performance Measures Applied

Performance measures and hydrologic targets developed for Lake Okeechobee are listed below. These performance measures are similar to those used in the Restudy (USACE and and were developed by Havens and Rosen (1999). These two references provide the background information and rationale for development of the following five priority performance measures for Lake Okeechobee, which were used to evaluate the lake:

- Number of times lake stages exceed 17 ft NGVD for greater than 50 days
- Number of times lake stages exceeded 15 ft NGVD for more than one year.
- Number of times lake stages fell below 12 ft NGVD for more than one year.
- Number of times lake stages fell below 11 ft NGVD
- Number of spring water level recessions, i.e., the number of times between the months of January and March that lake stages decline from near 15 ft NGVD to 12 ft NGVD. These conditions are judged as favorable for wading bird foraging and nesting and other aquatic dependent wildlife present within the littoral zone.

Base Cases and Alternatives Results

Table 22 provides an evaluation of the lake under the 1995 and 2020 base cases as compared to the 2020 with Restudy and LEC-1 water supply alternatives.

Table 22. Summary of Priority Performance Measures for Lake Okeechobee for the 31-Year Simulation.

Priority Performance Measures	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
No. of times stages > 17 ft NGVD	4	2	2	2
No. of times stages > 15 ft NGVD > 1 year	4	1	1	1
No. of times lake stage < 12 ft NGVD > 1 year	1	2	1	1
No. of times lake stages < 11 ft NGVD	4	19	4	4
Spring water level recession[a]	5	4	9	8

a. Number of years during the months of January – May that lake levels decline from near 15 to 12 ft NGVD (without an water level reversal > 0.5 ft.). These conditions are judged as favorable for wading bird foraging and nesting and also benefits other wildlife species present within the marsh. These water level recessions are also beneficial for reestablishing willow stands and also allow fire to burn away cattail thatch (Havens et al., 1998).

1995 Base Case. Under the 1995 Base Case there are an increased number of extreme high water events (number of times stages exceed 17 ft NGVD for more than a 50-days duration) that impact the littoral zone, increase the frequency that large volumes of water are discharged to downstream estuaries, and increase the risk of flooding of lakeside communities. In addition, the number of times that the littoral zone is flooded for long periods of time (number of times lake stages exceed 15.0 ft NGVD for more than one year) is higher than future water supply simulations. In contrast, the number of times that extreme low water events dry out the marsh and impact the ability of the lake to provide water supply for the LEC Planning Area (number of times lake stages fall below 11 and 12 ft NGVD) occurs less often under the 1995 Base Case (**Table 22**). The lake also has a fewer number of favorable spring water level recessions that benefit wading bird and snail kite foraging and nesting as compared to the 2020 with Restudy (**Table 22**).

2020 Base Case. Increased water demands under the 2020 Base Case lead to a significant increase in the number of times lake levels fall below 11 ft NGVD (19 times versus four times) as compared to the 1995 Base Case. This increase in low water periods has the potential to dry out the marsh more often and impact LEC water supplies. The 2020 Base Case shows an improvement in reducing the number of times that extreme high water conditions occur during the 31-year simulation when compared to the 1995 Base Case (**Table 22**). Although the number of lake dry downs increase under the 2020 Base Case, they do not appear to coincide with the spring water level recessions preferred by wading birds and other aquatic dependent species.

LEC 2020 with Restudy and LEC-1. Results show the LEC 2020 with Restudy and LEC-1 alternatives both performing significantly better than the base cases in meeting the five priority performance measures for Lake Okeechobee (**Table 22**). The most dramatic improvement occurs in terms of reduced number of extreme low lake stage events (i.e., lake stages which recede below 11 ft NGVD and completely dry out the littoral zone). Review of stage duration curves also showed improved hydrologic conditions within the littoral zone for the 2020 with Restudy and LEC-1 alternatives.

Littoral Zone Impacts. Under the 1995 Base Case simulation, the littoral zone was flooded 37 percent of the time during the 31-year simulation. These results are similar to current conditions on the lake which have resulted in prolonged flooding of the littoral zone resulting in loss of beneficial littoral zone plant communities in favor of introduced exotics (e.g., torpedo grass), as well as impacts to wading birds and other aquatic dependent wildlife. High lake stages have also been associated with increased in-lake nutrient loading, turbidity, and increased frequency of blue-green algal blooms (SFWMD, 1997).

Long-term flooding of the littoral zone was reduced significantly under the 2020 Base Case, the LEC 2020 with Restudy, and LEC-1 alternatives, which exhibited littoral zone flooding for 21, 18, and 16 percent of the time, respectively, during the 31-year model simulation. This is a major improvement over the 1995 Base Case condition. Although each of these runs resulted in a lower number of damaging high water events compared to the 1995 Base Case, only the LEC 2020 with Restudy and LEC-1 alternatives showed improved hydrologic benefits at both ends of the hydrograph (see **Appendix H** for hydrographs from model simulations).

Minimum Flows and Levels. Minimum water level criteria were met for the lake for the 1995 Base Case, the 2020 Base Case, the LEC 2020 with Restudy, and the LEC-1 simulations (**Table 23**). Best results occurred under the 1995 Base Case and the LEC 2020 with Restudy and LEC-1 alternatives, which showed water levels falling below 11 ft NGVD for greater than 80 days only twice (once every 15 years) during the 31-year simulation period. In contrast, increased water use demands, as observed for the 2020 Base Case, resulted in meeting the MFL criteria, although water levels dropped below 11 ft NGVD for more than an 80-day duration a total of five times (once every six years) during the 31-year simulation period. These results are just within the limits of meeting the proposed MFL criteria for Lake Okeechobee.

Table 23. Ability to Meet Proposed Minimum Water Level Criteria[a] for Lake Okeechobee for the 31-Year Simulation.

Performance Measure	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Number of times water levels fell below 11 ft NGVD for > 80 days duration	2 times (1-in-15 years)	5 times (1-in-6 years)	2 times (1-in-15 years)	2 times (1-in-15 years

a. MFL Planning Target = Water levels should not fall below 11 ft NGVD for greater than 80 days, no more often than once every 6 years

Incremental Simulations Results

Hydrologic Performance. Table 24 provides a summary of results for Lake Okeechobee for the incremental simulations with respect to meeting the five priority performance measures developed for the lake. The incremental modeling simulations shown in **Table 24** include the WSE schedule for Lake Okeechobee. Implementation of the WSE showed major improvements in reducing the number of times lake stages exceeded 17 ft NGVD. This reduction in the number of extreme high water events should help protect the ecosystem from the effects of damaging high water levels that impact the littoral zone and increase the risk of flooding.

Table 24. Incremental Modeling Results for Lake Okeechobee Priority Performance Measures.

Priority Performance Measure	1995 Revised Base Case	2005	2005 SSM Scenario	2010	2015	LEC-1 Revised
Number of times stages exceed 17 ft NGVD > 50 days	2	2	2	1	2	2
Number of times stages exceed 15 ft NGVD > 1 year	3	3	3	2	2	1
Number of times stages fell below 12 ft NGVD > 1 year	1	1	1	1	1	1
Number of times stages fell below 11 ft NGVD	8	12	11	9	5	3
Number of spring water level recessions[a]	5	5	5	5	6	10

a. Number of years during the months of January-March that stages decline from near 15 to 12 ft NGVD. These water level recessions are judged as favorable for wading bird foraging and nesting and also provide benefits to other aquatic dependent wildlife present within the littoral zone.

Incremental modeling results also show major improvements in reducing the number of times water levels fall below 11 ft NGVD, which helps protect the littoral zone and increases the District's ability to protect the Biscayne aquifer against saltwater intrusion during dry periods. This is the result of new regional reservoirs coming on line in 2010, 2015, and 2020 and implementation of the Lake Okeechobee ASR, which helps decrease demands on the lake during dry periods.

The number of spring water level recessions increases by 2020. This performance measure calculates the number of times lake stages decline during the months of January through March from near 15 to 12 ft NGVD. The timing of these water level recessions are favorable for wading bird foraging and nesting and also provide benefits to other aquatic dependent wildlife present within the littoral zone. **Table 24** shows gradual improvements over time, doubling the number of spring water level recession events by 2020.

Comparison of the LEC 2005 incremental simulation versus the 2005 SSM Scenario showed only minor differences in performance for Lake Okeechobee. The primary difference is that under the 2005 SSM Scenario there is slightly less water available in the lake during dry periods. However, this difference is not enough to exceed proposed MFL criteria for the lake (**Table 25**). Review of the five priority performance measures developed for Lake Okeechobee showed very similar performance for both simulations. Results from the 2005 incremental simulation and the 2005 SSM Scenario are presented in **Table 24**.

Minimum Flows and Levels. The water supply planning MFL criterion for the lake is as follows: *water levels should not fall below 11 ft NGVD greater than 80 days, no more often than once every six years on average*. **Table 25** presents incremental modeling results for how well the lake performed in meeting the proposed MFL criterion over the 20-year planning period. The MFL criterion was met for each incremental simulation with only a few exceptions: criterion was not met three times in the 2010 incremental simulation; two times in the 1995 Revised Base and the 2005 and 2015 incremental simulations; and only once in the 2020 incremental simulation. These values are well within the range of the proposed MFL target for Lake Okeechobee, which allows the MFL planning target to not be met five times during the 31-year simulation period.

Table 25. Lake Okeechobee Minimum Flows and Levels Incremental Results for the 31-Year Period of Record.

MFL Criterion	Target	1995 Revised Base Case	2005	2005 SSM Scenario	2010	2015	LEC-1 Revised
Number of times lake stages fell below 11 ft NGVD > 80 days	5 (1-in-6 years)	2 (1-in-15 yrs)	2 (1-in-15 yrs)	4 (1-in-8 yrs)	3 (1-in-10 yrs)	2 (1-in-15 yrs)	1 (1-in-30 yrs)

St. Lucie and Caloosahatchee Estuaries

Large releases of fresh water discharged from Lake Okeechobee and the associated local canal watersheds have contributed to poor water quality conditions and caused wide fluctuations of salinity to occur within both the St. Lucie and Caloosahatchee River estuaries. These high volume discharge events have increased turbidity and color problems, reduced light penetration, and caused salinity conditions that are too low to support important estuarine species (e.g., oysters). During high rainfall years, maximum mean monthly flows occasionally exceed 5,000 cfs for the St. Lucie Estuary and 7,000 cfs for the Caloosahatchee Estuary, causing each system to become entirely fresh water. These low salinity conditions result in the death of benthic invertebrates and displacement of other estuarine species and adversely impact aquatic productivity within these systems and adjacent waters of the Indian River Lagoon, San Carlos Bay, the Gulf of Mexico, and the Atlantic Ocean. Continuation of the present flow regime will not allow reestablishment of important benthic communities and submerged aquatic vegetation within the inner estuaries. In addition to the damaging effects of these high volume discharge events, the estuarine productivity has also been impacted by long-term freshwater discharges that sustain low salinity conditions throughout the estuary.

Another important consideration is the maintenance of base flows to these estuaries during dry periods. Chamberlain et al. (1995) reported salinities greater than 50 percent seawater (17 ppt) within the upper Caloosahatchee Estuary during prolonged low flow conditions. Similarly, relatively high salinity conditions, up to 80 percent of seawater (28 ppt), periodically occur in the St. Lucie Estuary. These relatively high salinity conditions (for an estuary) result in stress to estuarine organisms and reduction of their populations due to increased predation and parasites. Dry season low flow criteria proposed for the St. Lucie and Caloosahatchee estuaries represent preliminary attempts to establish performance measures for these systems. District staff are continuing to evaluate these criteria in ongoing efforts to develop science based minimum flow targets for each estuary.

St. Lucie Estuary

Performance Measures Applied

Three performances measures were developed to help evaluate SFWMM model results for the St. Lucie Estuary:

- Number of times mean monthly flow exceeds 3,000 cfs (high discharge criteria) as compared to target flow criteria
- Number of times mean monthly flow exceeds 2,000 cfs (recommended estuary protection criteria) as compared to target flow
- Number of months that low flow criteria were not met (flows less than 350 cfs from Lake Okeechobee and the C-44 Basin)

Base Cases and Alternatives Results

1995 Base Case. High lake stages and runoff from local basins result in an increased number of times large volumes of fresh water are discharged to the St. Lucie Estuary. Under the 1995 Base Case, the estuary experiences a high discharge event (mean monthly flows greater than 3,000 cfs) approximately once every year on average during the 31-year simulation (**Table 26**). Fresh water releases of this magnitude result in the entire inner estuary becoming fresh water for one month or longer. These types of high volume releases have a major impact on maintaining the estuary’s salinity regime, produce poor water quality, and significantly impact estuarine biota.

2020 Base Case. Increased water demands on Lake Okeechobee in 2020 result in reduced high volume releases to the estuary, but do not significantly improve the number of times estuarine protection criteria (mean monthly flow greater than 2,000 cfs) are exceeded (**Table 26**). This is an improvement over the 1995 Base Case, but is still far from the preferred management target.

Table 26. Number of Times Discharge Criteria Were Exceeded for the St. Lucie Estuary During the 31-Year Simulation Period.

Performance Measure	Target	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Number of times mean monthly flow exceeded 3,000 cfs (high discharge criteria)	5	30	19	8	8
Number of times mean monthly flows exceeded 2,000 cfs (recommended salinity envelop criteria)	23	60	56	27	28
Number of months that low flow criteria were not met (flows < 350 cfs)	178	150	158	51	127

LEC 2020 with Restudy and LEC-1. The number of high volume discharge events (mean monthly flows greater than 3,000 cfs) which impact the estuary were reduced by more than two-thirds compared to the 1995 Base Case and represent a major improvement in hydrologic performance. Both the LEC 2020 with Restudy and LEC-1 model simulations almost meet proposed performance targets for the St. Lucie Estuary (**Table 26**). Under these two water supply scenarios, mean monthly flows greater than 3,000 cfs (maximum discharge volumes) were exceeded only eight times during the 31-year simulation period, compared to 30 times for the 1995 Base Case and 19 times for the 2020 Base Case.

The LEC 2020 with Restudy and LEC-1 alternatives had fewer number of times when the recommended salinity envelope was exceeded (i.e., mean monthly flow volumes greater than 2,000 cfs). The 2020 with Restudy and LEC-1 model simulations showed only 27 and 28 instances of the criteria being exceeded, respectively, during the 31-year simulation as compared to 60 events for the 1995 Base Case and 56 events for the 2020 Base Case. In terms of the number of times that recommended low flow criteria were not met for the estuary, all simulations met the proposed low flow target (**Table 26**).

Incremental Results

Incremental modeling results show gradual improvements over time in reducing the number of high discharge events and reducing the number of times proposed estuary protection criteria were exceeded for the St. Lucie Estuary (**Table 27**). Significant reductions in these performance measures begin in 2010 as result of construction of regional storage reservoirs within the C-44 (St. Lucie) Basin and show continued improvement in 2015 and 2020. Likewise, the number of times proposed estuary protection criteria were exceeded for the estuary also showed improvement by 2010 for the same reasons. Incremental results also showed that estuary low flows targets were met for all years as shown in **Table 27**. Overall, these values were judged as close to meeting the environmental performance measure targets developed for the estuary and were therefore scored as green in **Table 21** as meeting planning targets.

Table 27. The Number of Times Discharge Criteria Were Exceeded for the 31-Year Simulation Period in the Incremental Simulations for the St. Lucie Estuary.

Performance measure	Target	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Number of times mean monthly flows exceed 3,000 cfs (high discharge criteria)	5	22	21	12	8	8
Number of times mean monthly flows exceed 2,000 cfs (estuary protection criteria)	23	61	56	38	28	29
Number of times low flow criteria were not met (flows< 350 cfs)	178	146	156	127	128	127

Caloosahatchee Estuary

Performance Measures Applied

Three performances measures were developed to help evaluate SFWMM model results for the Caloosahatchee Estuary:

- Number of times mean monthly flow exceeds 4,500 cfs (high discharge criteria) as compared to target flow criteria
- Number of times mean monthly flow exceeds 2,800 cfs (recommended estuary protection criteria) as compared to target flow
- Number. of months that low flow criteria were not met (flows less than 300 cfs from Lake Okeechobee and the C-43 Basin)

Base Cases and Alternatives Results

1995 Base Case. Results for the 1995 Base Case were similar to those observed for the St. Lucie Estuary. High lake stages and runoff from local basins result in an increased number of times that large volumes of freshwater were discharged to the Caloosahatchee Estuary. For the 1995 Base Case, the estuary experienced 36 high discharge events (mean monthly flows greater than 4,500 cfs) as compared to the target of only six events during the 31-year simulation period (**Table 28**). Freshwater releases of this magnitude result in the entire inner estuary becoming fresh water for one month or longer. These high volume releases have a major impact on maintaining the estuary's salinity regime, result in poor water quality, and impact estuarine biota.

2020 Base Case. Increased water demands on Lake Okeechobee in 2020 result in reduced high volume releases to the Caloosahatchee Estuary (28 events), and slightly reduce the number of times estuarine protection criteria (mean monthly flow greater than 2,800 cfs) are exceeded as compared to the 1995 Base Case (**Table 28**). This is an improvement over the 1995 Base Case, but is still far from the recommended target.

Table 28. Number of Times Discharge Criteria Were Exceeded for the Caloosahatchee Estuary During the 31-Year Simulation Period.

Performance Measure	Target	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Number of times mean monthly flow exceeded 4,500 cfs (high discharge criteria)	6	36	28	4	8
Number of times mean monthly flows exceeded 2,800 cfs (recommended salinity envelop criteria)	23	76	67	12	28
Number of months that low flow criteria were not met (flows < 300 cfs)	60	105	109	36	36

LEC 2020 with Restudy and LEC-1. Under these two water supply alternatives, mean monthly flows greater than 4,500 cfs (maximum discharge volumes) were exceeded only four times for the LEC 2020 with Restudy alternative simulation and eight times for LEC-1 alternative simulation, as compared to 36 times for the 1995 Base Case and 28 times for the 2020 Base Case. This represents a major improvement in hydrologic performance for the Caloosahatchee Estuary. The LEC 2020 with Restudy performs better than the recommended target for the estuary, while LEC-1 comes close to meeting the target (**Table 28**).

The LEC 2020 with Restudy and LEC-1 alternatives also produced fewer numbers of times when the recommended salinity envelope was exceeded (i.e., mean monthly flow volumes greater than 2,800 cfs). These two water supply alternatives resulted in only 12 and 28 failures to meet the criteria, respectively, during the 31-year simulation as compared to 76 events for the 1995 Base Case and 67 events for the 2020 Base Case.

In terms of the number of times that recommended low flow criteria were not met for the estuary, both the 2020 with Restudy and LEC-1 alternatives meet or performed better than the proposed low flow target**.**

Incremental Results

Incremental modeling results for the Caloosahatchee Estuary were similar to those recorded for the St. Lucie Estuary. **Table 29** shows gradual improvements over time in reducing the number of high discharge events and reducing the number of times proposed estuary protection criteria were exceeded for the Caloosahatchee Estuary**.** Significant reductions in the number of high discharges events begin in 2010 as result of construction of regional storage reservoirs within the C-43 (Caloosahatchee) Basin and show continued improvement in 2015 and 2020. Likewise, the number of times proposed estuary protection criteria were exceeded also showed improvement by 2010 for the same reasons. Incremental results also showed that estuary low flows targets were met for all years as shown in **Table 29**. Overall, these values met the environmental performance measure targets developed for the Caloosahatchee Estuary and were, therefore, scored green (**Table 21**) as meeting planning targets.

Table 29. The Number of Times Discharge Criteria Were Exceeded for the 31-Year Simulation Period in the Incremental Simulations for the Caloosahatchee Estuary.

Performance measure	Target	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Number of times mean monthly flows exceed 4,500 cfs (high discharge criteria)	6	33	29	13	9	8
Number of times mean monthly flows exceed 2,800 cfs (estuary protection criteria)	22	77	64	32	31	29
Number of times low flow criteria were not met (flows< 300 cfs from the lake and C-43)	60	146	153	76	36	36

Lake Worth Lagoon

The Lake Worth Lagoon is located along one of the most heavily urbanized areas of the LEC Planning Area. Historically the lagoon has been subject to inlet and channel dredging, shoreline bulkhead construction, draining and filling of adjacent wetlands, causeway and bridge construction, dock and marina development, industrial and sewage waste disposal, power plant operations, and stormwater runoff from three major South Florida drainage canals (C-51/S-155, C-51/S-41 and C-16/S-40). In general terms, problems associated with the Lake Worth Lagoon are similar to those experienced in other estuaries within the planning area. During high rainfall periods, large volumes of poor quality water are discharged into the lagoon from drainage basins located more than 20 miles west of the lagoon (e.g. C-51 Basin). These high discharge periods produce major impacts to both water quality and the salinity regime of the inner lagoon. While the cumulative impacts of these activities have significantly altered the character of the lagoon and diminished its value as a healthy estuarine ecosystem, it still supports a number of important natural resources and recreational values that should be protected.

Performance Measures Applied

Two performances measures were developed to help evaluate SFWMM model results for the Lake Worth Lagoon:

- Calculate the number of times a 14-day moving average exceeds 500 cfs during the 31-year simulation period. Preliminary modeling results obtained from Palm Beach County Department of Resource Management (DERM) indicates that flow discharges from these canals within the range of 500 cfs is roughly equivalent to a salinity of about 23 ppt within the lagoon under steady state conditions.
- Calculate average annual wet and dry season flows delivered to the Lake Worth Lagoon via C-51/S-155, C-16/S-40 and C-51/S-41 during the 31-year simulation period.

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Under current (1995) conditions the lagoon experiences a high number of high volume discharges events with 308 months out of 31-year simulation exceeding the 500 cfs target (**Table 30**). The magnitude of this discharge has resulted in large volumes of poor quality water discharged to the lagoon from upstream basins that drain urban and residential developments. These high volume discharge events impact both water quality and the salinity regime of the inner lagoon. Under the 2020 Base Case, the number of high discharge events are reduced by approximately 26 percent due in part to increased regional water supply demands and completion of STA-1 East as part of the Everglades Construction Project which divides the C-51 Basin and pumps water to the west from the developed areas within western Palm Beach County (known as the Acreage), Royal Palm Beach, and Wellington areas into STA-1 East for treatment and discharge into WCA-1.

Table 30. Number of Times Discharge Criteria Were Exceeded for the Lake Worth Lagoon During the 31-Year Simulation.

Performance Measure	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
Number of months 14-day moving average flow exceeded 500cfs	308	228	114	109
Mean annual wet and dry season flows discharged to the lagoon from S-155, S-40, and S-41	561	425	258	252

LEC 2020 with Restudy and LEC-1. These high volume discharge events are reduced even further under the LEC 2020 with Restudy and LEC-1 alternatives to only 114 and 109 high discharge events, respectively, during the 31-year simulation period. This is a 63 and 65 percent reduction, respectively, over the 1995 Base Case (**Table 30)**. This is due primarily to a number of water capturing features of the Restudy which routes water away from the lagoon and directs it west and south to the Everglades and other urban areas where water is needed. Because the Lake Worth Lagoon does not currently have an established science based flow/salinity target, it is uncertain whether a reduction in flows within this range will result in the desired result. For this reason District staff scored this area as yellow as it is uncertain whether planning targets can be met under these two proposed water supply alternatives due to lack of a clear restoration goal for the lagoon.

Incremental Results

Implementation of the Everglades Construction Project and STA-1E reduces high volume discharges to the lagoon as early as 2005. These improvements gradually increase over time and by 2020 show a 65 percent reduction in the total number of times flows exceed the 500 cfs target, and a 57 percent reduction in the total volume of water discharged to the lagoon as stormwater runoff (**Table 31).**

Table 31. The Number of Times Discharge Criteria Were Exceeded for the 31-Year Simulation Period in the Incremental Simulations for the Lake Worth Lagoon.

Performance Measure	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Number of months that 14-day moving average flows exceeded 500 cfs*	304	225	200	98	105
Mean annual wet and dray season flows discharged to the Lagoon from S-155, S-40 and S41 during the 31-year simulation.	556	427	395	227	241

Because a clearly defined environmental target has not yet been developed for Lake Worth, this area was scored yellow, indicating that it is uncertain whether flow reductions of this magnitude will benefit the ecosystem. As part of the *Interim Plan for Lower East Coast Regional Water Supply* (SFWMD, 1998b) a contract has been funded to work with Palm Beach County DERM to determine both minimum and maximum flow targets for the lagoon. This work is currently under way and should be completed within the next two years to develop science based environmental targets for the Lake Worth Lagoon.

Results for the Lake Worth Lagoon may need to be re-evaluated in future planning efforts. The physical location of the S-155A structure varies from its location in the SFWMM. It is modeled further east than its actual location, and therefore, the model may under estimate flows to the lagoon.

The Everglades

Performance Measures Applied

Performance measures for the Everglades were created with the intent of restoring the essential hydrological features of the natural system that existed prior to drainage and development of the region. Most of the performance measures used in this evaluation are similar to those used by the Restudy, with addition of MFL criteria for Lake Okeechobee, the Everglades, and the Biscayne aquifer. These performance measures were used to evaluate each model simulation's potential to (1) protect and support accretion of peat and marl soils, (2) protect tree island communities, and (3) maintain Everglades sawgrass or ridge and slough communities. The majority of performance measure targets for the Everglades were based on restoring the hydrological pattern predicted by the Natural Systems Model version 4.5 Final (NSM v4.5F), with a few exceptions. The performance measures applied are as follows:

- Ability to meet the Everglades minimum water level criteria presented in **Table 40** (SFWMD, 2000e)
- Meeting NSM-defined surface water inundation/duration patterns where appropriate
- Number and duration of extreme high and low water events

- Inter-annual depth variation (average and standard deviation of water depths for the months of May and October for the 31-year simulation period)
- Temporal variation in mean weekly stage
- Review of stage hydrographs and stage duration curves

More detailed descriptions of these performance measures and their associated targets can be found in Appendix D of this document.

Overview of Everglades Results

Model results for each alternative were evaluated at the level of individual indictor regions. An indictor region is a grouping of model grid cells within the SFWMM that consists of similar vegetation cover and soil type. These larger groupings of cells were developed to reduce the uncertainty of evaluating results from a single two by two square mile grid cell that represents a single water management gage or area. **Figure 4-13** provides the location of each indictor region evaluated in this study.

For final analysis, indictor regions that fell within areas of similar hydrological conditions or within the same impoundment system were grouped together. The final evaluation classified the indictor regions into 11 hydrological subregions of the Everglades:

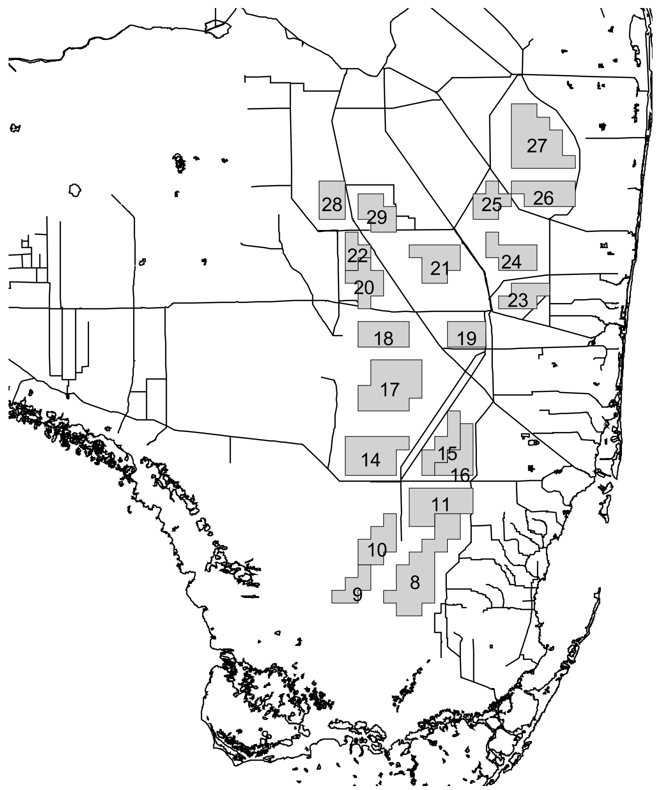

Figure 38. Everglades Indicator Regions used in the Analysis of Model Run Alternatives.

- Loxahatchee National Wildlife Refuge (LNWR, WCA-1): Indicator Regions 26 and 27
- Holey Land and Rotenberger WMAs: Indicator Regions 28 and 29
- WCA-2A: Indicator Regions 25 and 24
- WCA-2B: Indicator Region 23
- North WCA-3A: Indicator Regions 20, 21, and 22
- East WCA-3A: Indicator Region 19

- Central WCA-3A: Indicator Regions 17 and 18
- South WCA-3A: Indicator Region 14
- WCA-3B: Indicator Regions 15 and 16
- Shark River Slough: Indicator Regions 9, 10, and 11
- Rockland Marl Marsh: Indicator Region 8

The results of the base cases and alternatives simulations are presented by indicator region in **Tables 32**, **33**, and **34**. The results of the incremental simulations are presented in **Tables 35**, **36**, and **37**. These tables present several types of data: duration of average annual flooding (**Tables 32** and **35**); the number of weeks the low water depth criterion was exceeded (**Tables 33** and **36**); and the number of weeks the high water depth criteria was exceeded (**Tables 34** and **37**). The results will be discussed in detail by hydrological subregion.

Table 32. Duration of Average Annual Flooding in the Base Case and Alternative Simulations for the Everglades.[a]

Indicator Region	Area Name	Percent of Year				
		NSM[b]	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
8	Rockland Marl Marsh	65	29	46	58	55
9	SW Shark River Slough	98	88	91	96	96
10	Mid-Shark River Slough	100	92	93	98	98
11	NE Shark River Slough	100	87	88	97	97
14	South WCA-3A	92	98	93	95	95
15	West WCA-3B	92	96	92	97	98
16	East WCA-3B	95	89	83	96	96
17	South Central WCA-3A	87	94	88	95	95
18	North Central WCA-3A	89	91	90	97	97
19	East WCA-3A	86	99	93	92	93
20	NW WCA-3A	91	81	87	88	88
21	NE WCA-3A	85	74	92	83	85
22	NW Corner WCA-3A	91	76	92	94	95
23	WCA-2B	92	84	86	81	80
24	South WCA-2A	91	90	90	88	89
25	North WCA-2A	86	86	93	92	93
26	South WCA-1 (LNWR)	89	99	96	99	100
27	North WCA-1 (LNWR)	92	97	92	96	96
28	Rotenberger WMA	76	59	79	79	79
29	Holey Land WMA	88	96	96	88	88

a. Data from the Inundation Duration Summary.

b. NSM = Natural Systems Model version 4.5 Final

Table 33. Number of Weeks the Low Water Depth Criterion Was Exceeded in the Base Case and Alternative Simulations for the Everglades.[a]

Indicator Region	Area Name	Depth[b]	NSM[c]	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
8	Rockland Marl Marsh	< -1.5 ft	200	465	329	244	254
9	SW Shark River Slough	< -1 ft	5	72	39	17	14
10	Mid-Shark River Slough	< -1 ft	1	45	38	3	1
11	NE Shark River Slough	< -1 ft	1	59	50	6	4
14	South WCA-3A	< -1 ft	29	0	20	15	12
15	West WCA-3B	< -1 ft	5	1	9	6	4
16	East WCA-3B	< -1 ft	1	46	76	10	8
17	South Central WCA-3A	< -1 ft	55	21	53	12	11
18	North Central WCA-3A	< -1 ft	47	56	49	7	6
19	East WCA-3A	< -1 ft	60	0	29	31	17
20	NW WCA-3A	< -1 ft	36	119	66	48	44
21	NE WCA-3A	< -1 ft	106	194	45	79	65
22	NW Corner WCA-3A	< -1 ft	36	181	36	22	19
23	WCA-2B	< -1 ft	22	104	71	99	103
24	South WCA-2A	< -1 ft	46	62	62	86	70
25	North WCA-2A	< -1 ft	60	89	32	36	38
26	South WCA-1 (LNWR)	< -1 ft	37	0	4	0	0
27	North WCA-1 (LNWR)	< -1 ft	27	6	11	3	1
28	Rotenberger WMA	< -1 ft	136	297	86	56	56
29	Holey Land WMA	< -1 ft	84	6	10	43	42

a. The desired condition is to go below the low depth as few times as possible.

b. The low water depth criterion is -1.0 feet below ground for peat forming wetlands and -1.5 feet below ground for marl forming marshes.

c. NSM = Natural Systems Model version 4.5 Final

Table 34. Number of Weeks the High Water Depth Criterion Exceeded in the Base Case and Alternative Simulations for the Everglades.[a]

Indicator Region	Area Name	Depth[b]	NSM[c]	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
8	Rockland Marl Marsh	>2 ft	0	0	0	0	0
9	SW Shark River Slough	>2.5 ft	0	0	0	0	0
10	Mid-Shark River Slough	>2.5 ft	56	1	0	19	18
11	NE Shark River Slough	>2.5 ft	144	0	0	53	46
14	South WCA-3A	>2.5 ft	0	599	114	12	14
15	West WCA-3B	>2.5 ft	38	13	89	55	52
16	East WCA-3B	>2.5 ft	65	26	164	95	85
17	South Central WCA-3A	>2.5 ft	0	65	40	15	18
18	North Central WCA-3A	>2.5 ft	0	32	16	14	17
19	East WCA-3A	>2.5 ft	0	877	235	322	373
20	NW WCA-3A	>2.5 ft	0	1	1	0	0
21	NE WCA-3A	>2 ft	3	15	13	32	38
22	NW Corner WCA-3A	>2.5 ft	0	0	0	0	0
23	WCA-2B	>2.5 ft	20	246	790	162	131
24	South WCA-2A	>2.5 ft	0	2	10	55	73
25	North WCA-2A	>2.5 ft	0	0	0	12	17
26	South WCA-1 (LNWR)	>2.5 ft	0	486	371	405	436
27	North WCA-1 (LNWR)	>2.5 ft	0	4	1	1	1
28	Rotenberger WMA	>1.5 ft	76	0	0	0	0
29	Holey Land WMA	>1.5 ft	182	602	628	115	114

a. The desired condition is to exceed the high water depth as few times as possible.

b. The low water depth criterion is -1.0 feet below ground for peat forming wetlands and -1.5 feet below ground for marl forming marshes.

c. NSM = Natural Systems Model version 4.5 Final

Table 35. Duration of Average Annual Flooding in the Incremental Simulations for the Everglades.[a]

Indicator Region	Area Name	Percent of the Year					
		NSM[b]	1995 Revised Base	2005	2010	2015	LEC-1 Revised
8	Rockland Marl Marsh	65	29	58	51	53	55
9	SW Shark River Slough	98	88	89	91	92	96
10	Mid-Shark River Slough	100	92	90	92	94	98
11	NE Shark River Slough	100	87	87	86	91	97
14	South WCA-3A	92	98	98	92	91	95
15	West WCA-3B	92	96	96	93	93	98
16	East WCA-3B	95	89	88	90	90	96
17	South Central WCA-3A	87	94	93	90	93	95
18	North Central WCA-3A	89	91	89	94	98	97
19	East WCA-3A	86	98	99	91	91	93
20	NW WCA-3A	91	80	81	87	91	88
21	NE WCA-3A	85	74	87	85	84	83
22	NW Corner WCA-3A	91	76	85	91	94	94
23	WCA-2B	92	84	74	78	82	83
24	South WCA-2A	91	90	86	89	91	91
25	North WCA-2A	86	86	92	89	92	93
26	South WCA-1 (LNWR)	89	99	96	97	98	99
27	North WCA-1 (LNWR)	92	96	92	94	95	96
28	Rotenberger WMA	76	59	74	79	79	79
29	Holey Land WMA	88	96	96	87	88	88

a. Data from Inundation Duration Summary for the incremental simulation

b. NSM = Natural Systems Model version 4.5 Final

Table 36. Number of Weeks the Low Water Depth Criterion Exceeded in the Incremental Simulations for the Everglades.[a]

Indicator Region	Area Name	Depth[b] (ft)	NSM[c]	1995 Revised Base	2005	2010	2015	LEC-1 Revised
8	Rockland Marl Marsh	< -1.5	200	470	321	336	309	263
9	SW Shark River Slough	< -1	5	71	64	51	44	12
10	Mid-Shark River Slough	< -1	1	45	60	46	31	5
11	NE Shark River Slough	< -1	1	60	67	61	30	6
14	South WCA-3A	< -1	29	0	1	36	32	13
15	West WCA-3B	< -1	5	1	2	27	29	5
16	East WCA-3B	< -1	1	47	46	60	55	9
17	South Central WCA-3A	< -1	55	21	28	40	24	13
18	North Central WCA-3A	< -1	47	56	55	31	5	6
19	East WCA-3A	< -1	60	1	0	47	35	25
20	NW WCA-3A	< -1	36	123	121	63	28	43
21	NE WCA-3A	< -1	106	195	97	104	85	91
22	NW Corner WCA-3A	< -1	36	185	92	35	22	14
23	WCA-2B	< -1	22	110	184	142	105	89
24	South WCA-2A	< -1	46	64	81	70	56	60
25	North WCA-2A	< -1	60	87	43	65	34	33
26	South WCA-1 (LNWR)	< -1	37	0	2	2	1	0
27	North WCA-1 (LNWR)	< -1	27	6	13	6	4	1
28	Rotenberger WMA	< -1	136	297	163	57	57	56
29	Holey Land WMA	< -1	84	6	9	44	43	41

a. The desired condition is to go below the low water depth as few times as possible.

b. The low water depth criterion is -1.0 feet below ground for peat forming wetlands and -1.5 feet below ground for marl forming marshes.

c. NSM = Natural Systems Model version 4.5 Final

Table 37. Number of Weeks the High Water Depth Criterion Exceeded in the Incremental Simulations for the Everglades.[a]

Indicator Region	Area Name	Depth[b] (ft)	NSM[c]	1995 Revised Base	2005	2010	2015	LEC-1 Revised
8	Rockland Marl Marsh	>2	0	0	0	0	0	0
9	SW Shark River Slough	>2.5	0	0	0	0	0	0
10	Mid-Shark River Slough	>2.5	56	1	13	15	15	20
11	NE Shark River Slough	>2.5	144	0	49	20	20	52
14	South WCA-3A	>2.5	0	593	108	58	65	12
15	West WCA-3B	>2.5	38	13	52	3	3	51
16	East WCA-3B	>2.5	65	22	67	19	20	89
17	South Central WCA-3A	>2.5	0	64	23	27	28	14
18	North Central WCA-3A	>2.5	0	30	11	22	21	13
19	East WCA-3A	>2.5	0	860	315	137	144	351
20	NW WCA-3A	>2.5	0	1	0	6	2	0
21	NE WCA-3A	>2	3	15	6	26	25	30
22	NW Corner WCA-3A	>2.5	0	0	0	0	0	0
23	WCA-2B	>2.5	20	235	181	141	151	158
24	South WCA-2A	>2.5	0	2	0	52	53	58
25	North WCA-2A	>2.5	0	0	0	10	12	11
26	South WCA-1 (LNWR)	>2.5	0	475	429	488	506	510
27	North WCA-1 (LNWR)	>2.5	0	4	8	8	11	11
28	Rotenberger WMA	>1.5	76	0	0	0	0	0
29	Holey Land WMA	>1.5	182	599	706	114	105	108

a. The desired condition is to exceed the high water depth as few times as possible.

b. Depth = the low water depth criterion

c. NSM = Natural Systems Model version 4.5 Final

Loxahatchee National Wildlife Refuge (WCA-1)

Base Cases and Alternatives Results

1995 and 2020 Base Cases. The current U.S. Fish and Wildlife Service's (USFWS's) regulation schedule for the Loxahatchee National Wildlife Refuge (WCA-1) is in effect under the 1995 Base Case and was adopted as the performance target for the refuge at the request of refuge staff. Under these conditions this area meets the proposed target and, therefore, was scored green for the 1995 Base Case (**Table 20**). Increased regional water supply demands under the 2020 Base Case showed a tendency toward slightly lower water levels and shorter hydroperiods as compared to the 1995 Base Case target. Overall, there is approximately a five percent shorter annual period of flooding (**Table 32**) and smaller increases in the number of weeks that the low water criterion was exceeded (**Table 33**). Because of these factors, this area was scored yellow for the 2020 Base Case (**Table 20**).

LEC 2020 with Restudy and LEC-1. Conditions in the Loxahatchee National Wildlife Refuge (WCA-1) meet the target for both alternatives. This includes both the northern (Indicator Region 27) and southern (Indicator Region 26) sections. The refuge was scored green as meeting proposed environmental performance targets under the 2020 with Restudy and LEC-1 model simulations (**Table 20**).

Incremental Results

The current USFWS's regulation schedule for the Loxahatchee National Wildlife Refuge (WCA-1) is in effect under the 1995 Base Case and was adopted as the performance target for area. Under these conditions this area meets the proposed target and, therefore, was scored green for the 1995 Base Case (**Table 21**). Increased regional water supply demands under the 2020 Base Case showed a tendency toward slightly lower water levels as compared to the 1995 Base Case. Overall, there is a shorter annual period of flooding (**Table 35**) and small increases in the number of weeks that the low water criterion was exceeded (**Table 36**). Because of these factors, this area was scored green/ yellow for 2005 (**Table 21**). However, by 2010, conditions in the Loxahatchee National Wildlife Refuge (WCA-1) closely match the 1995 Revised Base Case for the remaining future alternatives. This includes both the northern (Indicator Region 27) and southern (Indicator Region 26) sections. The Loxahatchee National Wildlife Refuge (WCA-1) met proposed environmental performance targets under the 2010, 2015, and 2020 simulations and was scored green (**Table 21**).

Water Conservation Area 2A

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Water levels were consistently higher and fluctuated over a wider range of water depths as compared to the NSM target in the 1995 and 2020 base cases for WCA-2A. In particular, northern WCA-2A (Indicator Region 25) exhibited wet and dry season water depth ranges in excess of targets that were defined on the basis of the NSM (**Tables 33** and **34**). The deeper water levels are presumed to be undesirable for the recovery and maintenance of the remaining tree islands. WCA-2A also experienced increased number of weeks that the low-water depth criterion (number of times that water levels fell more than one foot below ground) was exceeded under the base cases (**Table 33**). These events are undesirable for the protection and accretion of peat soils. Although southern WCA-2A (Indicator Region 24) performed better, wet season surface water ponding generally elevated water levels above the target range based on the NSM. WCA-2A was scored green/yellow to account for differences in performance between northern and southern WCA-2A (**Table 20**).

LEC 2020 with Restudy and LEC-1. WCA-2A did not perform better in the LEC 2020 with Restudy or LEC-1 alternatives, retaining a score of green/yellow. (**Table 20**) Performance between the base cases and the alternatives were very similar. The main difference is the high water criterion (number of weeks water depths exceeded 2.5 feet) was exceeded more weeks in the alternatives than in the base cases (**Table 34**). It appears that water management in this area creates trade-offs between flooding and drying that are difficult to balance. Operational parameters may be further refined to bring the performance of this area closer to the NSM target.

Incremental Results

Overall, WCA-2A performed moderately in the 1995 Revised Base Case and showed no improved performance throughout the incremental scenarios. Water levels were consistently higher and fluctuated over a wider range of water depths as compared to the NSM target (**Table 37**). In particular, north WCA-2A (Indicator Region 25) exhibited wet and dry season water depth ranges in excess of NSM-defined targets. These prolonged deep water conditions are undesirable for the recovery and maintenance of the remaining tree islands. WCA-2A also experienced increased number of weeks that the low water depth criterion was exceeded. These events are undesirable for the protection and accretion of peat soils. Although south WCA-2A (Indicator Region 24) performed better, wet season surface water ponding generally elevated water levels above the target range. WCA-2A has been scored green/yellow for the 1995 Revised Base Case and all of the incremental scenarios (**Table 21**).-

Water Conservation Area 2B

Base Cases and Alternatives Results

1995 and 2020 Base Cases. WCA-2B (Indicator Region 23) performed poorly in both the 1995 and 2020 base cases. Water levels were much higher and much more variable as compared to the NSM target (**Table 34**). Inundation patterns are of much longer duration (**Table 32**), with more frequent and extreme high water and low water periods (**Tables 33** and **34**). The high water criterion (number of weeks the surface water depth is greater than 2.5 feet) is exceeded 50 percent of the time in the 2020 Base Case. These sustained inundation depths near or greater than 2.5 feet would be detrimental to tree island and sawgrass communities within this WCA. Annual amplitudes of depth between wet and dry seasons were larger than the target. Many of the problems in this area are due to its relatively small size; its location above the Biscayne aquifer, which results in large seepage losses; its unusual shape that promotes ponding in the south end; and its position in the landscape. Because of the magnitude of difference between the NSM target and the 1995 Base Case, this area has been scored red (**Table 20**).

LEC 2020 with Restudy and LEC-1. Although a number of different management strategies (e.g. rainfall-driven system versus regulation schedule) have been tried within the SFWMM alternatives, few have been successful in meeting NSM targets for this area. The LEC 2020 with Restudy and LEC-1 alternatives continue to have problems meeting both high water and low water criteria (**Tables 33** and **34**). However, the LEC-1 simulation performs better than the LEC 2020 with Restudy. Although the severity of these events in the base cases have been moderated, there still is significant deviation from the NSM target to score this area as red (**Table 20**).

Incremental Results

WCA-2B (Indicator Region 23) performed poorly in both the 1995 Revised Base Case and throughout the incremental alternatives (2005 through 2020). In the 1995 Revised Base Case, water levels were much higher and much more variable as compared to the NSM target (**Tables 36** and **37**). Inundation patterns are of much longer duration (**Table 35**), with more frequent and extreme high water and low water periods (**Tables 36** and **37**). The high water criterion is often exceeded. Sustained inundation depths near or greater than 2.5 feet would be detrimental to tree island and sawgrass communities within this WCA. Annual amplitudes of depth between wet and dry seasons were larger than the target. Although problems with high water improve somewhat through time, a significant increase in drying events occurs. For all alternatives, WCA-2B has been scored red (**Table 21**). ALTD13R of the Restudy recognized this problem and arrived at the same conclusions (USACE and SFWMD, 1999). Many of the problems in this area are due to its relatively small size; its location above the Biscayne aquifer, which results in large seepage losses; its unusual shape that promotes ponding in the south end; and its position in the landscape.

Holey Land and Rotenberger Water Management Areas

Base Cases and Alternatives Results

1995 and 2020 Base Cases. For the 1995 and 2020 base cases, the Holey Land WMA (Indicator Region 29) has higher water levels than the NSM target (**Table 34**). This is due to the fact that the Florida Fish and Wildlife Conservation Commission’s (FFWCC’s) regulation schedule is in effect. The number of weeks that the high water depth criterion is exceeded is more than 600, more than three times the target (**Table 34**). Water levels exceed the high water criterion for approximately 35 percent of the year and there are infrequent low water periods. For this reason, this area has been scored yellow. In contrast, the Rotenberger WMA (Indicator Region 28) has a much shorter annual average inundation period than the target (**Table 32**) in the 1995 Base Case. This area has more than double the number of weeks that the low water depth criterion (one foot below the soil surface) has been exceeded (**Table 33**), and for this reason, the

Rotenberger WMA has been scored red for the 1995 Base Case (**Table 20**). In the 2020 Base Case, conditions improve greatly in this WMA due to the operation of upstream STAs. In the 2020 Base Case, the Rotenberger WMA has been scored green (**Table 20**).

LEC 2020 with Restudy and LEC-1. Conditions in the Holey Land and Rotenberger WMAs are much improved in both the LEC 2020 with Restudy and LEC-1 alternatives. Water levels are maintained near that of the NSM target (**Tables 33** and **34**), and for this reason they both have been scored green for these alternatives (**Table 20**).

Incremental Results

Generally, the Holey Land and Rotenberger WMAs showed incremental improvements over the Base Case conditions and NSM-defined targets were met by 2010. For the 1995 Revised Base Case and 2005 SSM Scenario, the Holey Land WMA (Indicator Region 29) has higher water levels than the NSM target (**Table 37**). This is due to the fact that the FFWCC's regulation schedule is in effect. The number of weeks that the high water depth criterion is exceeded is more than three times the target. Water levels exceed the high water criterion for more than 30 percent of the year (**Table 37**) and there are infrequent low water periods (**Table 36**). For this reason, this area has been scored red for the 1995 Revised Base Case and the 2005 incremental simulation. In contrast, the Rotenberger WMA (Indicator Region 28) has a much shorter annual average inundation period than the target in the 1995 Revised Base Case. This area has more than double the number of weeks that the low water depth criterion (one foot below the soil surface) has been exceeded (**Table 36**), the Rotenberger WMA has been scored red for the 1995 Base Case. By 2005, conditions improve greatly in this WMA due to the operation of upstream STAs. By the 2010 Base Case, the Rotenberger WMA has been scored green. (**Table 21**). Conditions in the Holey Land and Rotenberger WMAs are improved by 2010 and performance is near that of the NSM target. For this reason they both have been scored green for years 2010, 2015, and 2020 (**Table 21**).

North Water Conservation Area 3A

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Northeast WCA-3A (Indicator Region 21) performed poorly in the 1995 Base Case. In general, this area has a problem with both high and low water extremes (**Tables 33** and **34**). This area has 11 percent less average annual duration of flooding (**Table 32**), indicating that more severe drying events will occur. Performance improved somewhat in the 2020 Base Case, prompting a change from a red score in the 1995 Base Case to yellow in the 2020 Base Case (**Table 20**).

In the 1995 Base Case, northwest WCA-3A (Indicator Regions 20 and 22) suffers from chronic low water conditions and tends toward extreme drying in most years. As compared to the NSM target, the average period of annual flooding is more than 10 percent shorter, resulting in extended periods of more severe drying. Because of the problems present in the 1995 Base Case, north WCA-3A has been scored red (**Table 20**). Under the 2020 Base Case, conditions improved significantly with the operation of the

STAs to the north of WCA-3A. This increased hydroperiod gives this area more NSM-like hydrology. Therefore, north WCA-3A has been scored green for the 2020 Base Case (**Table 20**).

LEC 2020 with Restudy and LEC-1. In both the 2020 with Restudy and LEC-1 alternatives, north WCA-3A performs well and shows much improvement over the 1995 and 2020 base cases. The hydropatterns are NSM-like, aided by the operation of the EAA Reservoir, the completed STAs to the north and other Restudy components. This area has been scored green in both alternatives (**Table 20**).

Incremental Results

Generally, north WCA-3A showed incremental improvements over the Base Case conditions and NSM-defined targets were met by 2010. Northern WCA-3A (Indicator Regions 20, 21, and 22) performed poorly in the 1995 Revised Base Case. In general, this area has a problem with drying and exceedance of the low water criterion (depth less than one foot below the soil surface) (**Table 36**). Performance improved somewhat in 2005, prompting a change from a red score in the 1995 Revised Base Case to green/yellow (**Table 20**). By 2010, NSM targets are met in all north WCA-3 indictor regions, and this trend continues through 2020. Much of this improvement can be attributed to the construction and operation of STAs, and completion of the EAA Reservoir along the northern boundary of WCA-3A.

East Water Conservation Area 3

Base Cases and Alternatives Results

1995 and 2020 Base Cases. East WCA-3A (Indicator Region 19) performed poorly in the 1995 Base Case. Water levels were much higher and much more variable than in the NSM target (**Table 34**). Inundation patterns are of much longer duration, with more frequent and extreme high water periods. The high water depth criterion was exceeded approximately 55 percent of the time (**Table 34**). Under this scenario, this area has been scored red. Performance improved some in the 2020 Base Case. Prolonged high water events have been reduced, although there still is much longer annual flooding than the NSM target (**Table 32**). In the 2020 Base Case, eastern WCA-3A was scored as yellow, indicating marginal ability to meet LEC planning targets.

LEC 2020 with Restudy and LEC-1. East WCA-3A continues to be scored yellow in the 2020 with Restudy and LEC-1 alternatives. Problems of longer annual flooding (**Table 32**) and more weeks that the high water criterion has been exceeded (**Table 32**) than the NSM target continue to exist, similar to those seen the 2020 Base Case.

Incremental Results

East WCA-3A (Indicator Region 19) performed poorly in the 1995 Revised Base Case. Water levels were much higher and much more variable than in the NSM target.

Inundation patterns (**Table 35**) are of much longer duration, with more frequent and extreme high water periods (**Table 37**). Under this scenario, this area has been scored red. Performance improved in 2005. Prolonged high water events have been reduced, although there still is much longer annual flooding than the NSM target (**Table 35**). No further improvements were seen through 2020. Eastern WCA-3A was scored as yellow for the years 2005 through 2020 (**Table 21**), indicating marginal or uncertain ability to meet LEC planning targets.

Central Water Conservation Area 3A

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Central WCA-3A (Indicator Regions 17 and 18) generally of have an increased number of extreme high water events and longer duration of flooding as compared to the NSM target for this area. Indicator region 18 recorded both extreme high and extreme low water levels (**Tables 33** and **34**) and was scored red for the 1995 and 2020 base cases. For Indicator region 17, this area exhibited a number of extreme high water events that potentially could impact existing tree island vegetation within the central portion of WCA-3A. For this reason this area was scored yellow under the 1995 and 2020 bases cases.

LEC 2020 with Restudy and LEC-1. Central WCA-3A showed a number of improvements in both hydropattern (more NSM-like) and reduction of extreme high water events for the 2020 with Restudy and LEC-1 alternatives. Indicator Region 17 located within the central portion of WCA-3A performed well with respect to meeting NSM targets and was scored green. In contrast, Indicator 18 exhibited prolonged hydroperiods in excess of the NSM target (**Table 32**) but did show a reduction in the number of both extreme high and low water events (**Tables 33** and **34**) as compared to the bases cases. Prolonged hydroperiods exhibited by the 2020 with Restudy and LEC-1 appear to be the result of the relocation pump station S-140 south of Alligator Alley which moves a good deal more water across Indicator Region 18, thus preventing the area from drying out. For these reasons Indicator Region 18 was scored yellow.

Incremental Results

In the 1995 Revised Base Case, central WCA-3A (Indicator Regions 17 and 18) generally experienced an increased number of extreme high water events and had longer duration of flooding as compared to the NSM target (**Tables 36** and **37**). Under the 1995 Revised Base Case there were increased number of extreme high water events that potentially could cause damage to existing tree island communities. For this reason this area was scored as red for Indicator Region 18, and yellow for Indicator Region 17

By 2005, Indicator Region 17 showed improvement in meeting MFLs and NSM hydropattern targets, as well as recording a reduction in the number extreme high water events (**Tables 36** and **37**) In contrast, Indicator Region 18 remained problematic with prolonged hydroperiods in excess of the NSM target. Again these problems appear to be associated with the relocation of pump station S-140 which discharges large volumes of water across Indicator Region 18 preventing the area from drying out. For these reasons Indicator Region 17 was scored green and Indicator Region 18 was scored yellow for the 2005 through 2015 incremental simulations and the LEC-1 Revised.

South Water Conservation Area 3A

Base Cases and Alternatives Results

1995 and 2020 Base Cases. In the base cases, water in south WCA-3A (Indicator Region 14) tends to pond and there is excessive flooding. Here, the high water depth criterion is exceeded more than 35 percent during the 31-year simulation (**Table 34**). This condition is unfavorable for the protection of tree island or sawgrass communities. Because of the extreme nature of these problems, this area has been scored red in both base cases (**Table 20**).

LEC 2020 with Restudy and LEC-1. In both the 2020 with Restudy and LEC-1 alternatives, south WCA-3A performs well. The hydropatterns are NSM-like and are greatly improved over the 1995 and 2020 base cases. This area has been scored green in both alternatives (**Table 20**).

Incremental Results

South WCA-3A showed gradual improvement from the 1995 Revised Base Case through 2020. In 1995, water in south WCA-3A (Indicator Region 14) tends to pond and there is excessive flooding. This condition is unfavorable for the protection of tree island or sawgrass communities. Because of the extreme nature of the high water problems, this area has been scored red for the 1995 Revised Base Case (**Table 21**). Improvement of performance is seen in years 2005, 2010, and 2015, where the severity of high water problems has been moderated. However, the NSM-defined targets are not met during these time frames, so a score of yellow has been assigned to these scenarios (**Table 21**). By 2020, south WCA-3A performs well with hydropatterns that are similar to the NSM target. This area is scored green for year 2020 (LEC-1 revised) alternative (**Table 21**).

Water Conservation Area 3B

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Overall, WCA-3B performs similar to the NSM target in terms of pattern of inundation (duration and frequency) (**Table 32**). West WCA-3B (Indicator Region 15) tends to have more water during the dry season than the target (**Table 36**), leading to fewer years of drawdown. Conversely, east WCA-3B (Indicator Region 6) tends to have less water in the dry season than the target, leading to a higher number of weeks that the low water depth criterion is exceeded (**Table 36**). With some alteration of operational components, these problems may be resolved. For this reason, this area has been scored yellow for both base cases (**Table 20**).

LEC 2020 with Restudy and LEC-1. Differences between the NSM target performance and that of WCA-3B remain unresolved in the 2020 with Restudy and LEC-1 alternatives. This area continues to be scored yellow in these alternatives (**Table 20**).

Incremental Results

WCA-3B performed moderately in the 1995 Revised Base Case. Overall, the pattern of inundation (duration and frequency) was mostly similar to the NSM target (**Table 35**). West WCA-3B (Indicator Region 15) tends to have more water during the dry season than the target, leading to fewer years of drawdown. Conversely, east WCA-3B (Indicator Region 6) tends to have less water in the dry season than the target, leading to a higher number of weeks that the low water depth criterion is exceeded (**Table 36**). Conditions did not improve significantly until 2020, when additional operational and structural component changes supported resolution of some of these problems. For this reason, this area has been scored yellow for the 1995 Revised Base Case through 2015 incremental simulations (**Table 21**). Persisting differences between the NSM target and that of WCA-3B's performance in 2020 led us to score this area as green/yellow for the 2020 incremental simulation (**Table 21**).

Shark River Slough

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Northeast Shark River Slough (Indicator Region 11) has much less water and dries out more often in the 1995 and 2020 Base Cases as compared to the NSM target. In addition, the low water depth criterion was exceeded more often (**Table 33**) and the duration of annual flooding (hydroperiod) is significantly less (**Table 32**) under both base cases when compared to the NSM target. Similar problems with low water levels and increased number of dry downs exist in central Shark River Slough (Indicator Regions 9 and 10) under the base cases. This excessive drying is unfavorable for development or preservation of peat soils and protection of wetland plant and animal communities. For this reason, this area was scored red for both the 1995 and 2020 base cases (**Table 20**).

LEC 2020 with Restudy and LEC-1. The performance of the 2020 with Restudy and LEC-1 alternatives for Shark River Slough is much improved compared to the base cases. Significantly more water is delivered to the system which increases the duration of annual flooding and reduces the number times this area dries out as compared to the base cases. Improvements both in the quantity and timing of water delivered Shark River Slough are due primarily to a number of the Restudy projects coming on line by 2020. These components include the completion of 50 percent of the Lake Belt Storage and Conveyance components, decompartmentalization of WCA-3, and enhanced flows under Tamiami Trail. Because performance is significantly improved over the base cases, but still does not quite meet the NSM target, this area was scored as green/yellow (**Table 20**.

Incremental Results

Shark River Slough (Indicator Regions 9, 10, and 11) has much less water in the 1995 Revised Base Case and 2005 incremental simulation than the NSM target. The number of weeks that the low water depth criterion has been exceeded is higher (**Table 36**) and the duration of annual flooding is significantly less (**Table 35**). This excessive drying is unfavorable for development or preservation of peat soils and protection of wetland plant and animal communities. Furthermore, there is a tendency toward early dry season recession of the surface water. This can be problematic for wildlife species that rely on the timing of the dry season dry downs for foraging or reproduction cycles. For this reason, Shark River Slough has been scored red for both the 1995 Revised Base Case and 2005 incremental simulation (**Table 21**).

Modeling results show a gradual improvement over time in providing increased flows delivered to Everglades National Park. Beginning in 2005, a significant improvement in both the distribution and volume of water delivered to northeast and northwest Shark River Slough occurs (**Table 38**). By 2010 significant improvements in meeting NSM hydroperiod targets were recorded within northeast and central Shark River Slough, with near full recovery by 2020 (100 percent of the slough matches the NSM hydroperiod target by 2020) (**Table 39**). However, because performance is still short of the target, this area has been scored green/yellow (**Table 21**).

Table 38. Total Average Annual Flows Discharged into northern Everglades National Park, east and west of L-67A (1000 acre-ft)

Area	Average Annual Flow (acre-feet x 1,000)				
	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
NW Shark River Slough	461	568	397	434	579
NE Shark River Slough	88	402	524	596	685
Total	549	970	921	1030	1264

Table 39. Mean NSM Hydroperiod Matches with Respect to NSM[a].

Area	1995 Revised Base Case	2005	2010	2015	LEC-1 Revised
Remaining Everglades	58%	64%	74%	77%	78%
Everglades National Park	54%	60%	66%	75%	87%
Shark River Slough (ENP)	53%	44%	71%	95%	100%
Rockland Marl marsh	49%	70%	65%	67%	75%
WCA System	64%	69%	80%	79%	75%
Northern WCA-3A	43%	64%	78%	75%	76%

a. Match corresponds to a match with the NSM target +30 hydroperiod days

Rockland Marl Marsh

Base Cases and Alternatives Results

1995 and 2020 Base Cases. The Rockland Marl Marsh area of Everglades National Park (Indicator Region 8) performed poorly in both the 1995 and 2020 base cases. This area has problems with extremely low water levels, often exceeding the low water depth criterion (**Table 33**). This excessive drying is unfavorable for development or preservation of marl soils. This area has been scored red for both base cases (**Table 20**).

LEC 2020 with Restudy and LEC-1. The LEC 2020 with Restudy and LEC-1 alternatives show significantly improved performance for the Rockland marl marsh. More water is delivered to the system and the hydroperiod is much closer to the NSM target than for the base cases. Because performance is still short of the target, this area has been scored yellow (**Table 20**).

Incremental Results

The Rockland marl marsh area of Everglades National Park (Indicator Region 8) performed poorly in the 1995 Revised Base Case. This area exceeds the low water depth criterion significantly more then the NSM target. The excessive drying is unfavorable for development or preservation of marl soils, and a score of red has been assigned to the 1995 Revised Base Case (**Table 21**).

The incremental simulations show improved performance through time. By 2005, more water is delivered to the system and the hydroperiod is much closer to the NSM target than for the base cases. Performance continued to improve from 2005 through 2020, shown by sequential decreases in the number of weeks that the low water depth criterion was exceeded (**Table 36**) and closer hydroperiod matches to the NSM-defined target (**Table 39).** Although significant hydroperiod improvements were noted, this area has been scored yellow to indicate that performance is still short of the NSM target in 2020 (**Table 18**). Alternative D13R from the Restudy indicated similar problems with lowered water levels for the Rockland Marl marsh (USACE and SFWMD, 1999).

Minimum Flows and Levels

Base Cases and Alternatives Results

Table 40 provides a summary of the proposed MFL criteria for the Everglades (SFWMD, 2000e). **Table 41** provides a summary of the results for meeting the proposed criteria for the 1995 and 2020 base cases at selected water management gage locations in the Everglades.

1995 Base Case. Model simulations show that under the 1995 Base Case proposed minimum water level criteria are not met for 12 out of 19 indictor regions located within the northern Everglades and Everglades National Park. This is due largely to impoundment of these marshes and the construction of major canals through the

Table 40. Minimum Water Level, Duration, and Return Frequency Performance Measures for Selected Water Management Gages Located within the Everglades (SFWMD, 2000e).

Area	Key Gage	Indicator Region[a]	Soil Type	Minimum Depth (ft) and Duration (days)	Return Frequency (years)[b]
Water Conservation Areas					
LNWR	1-7	27	Peat	-1.0 ft >30 days	1-in-4
WCA-2A	2A-17	24	Peat	-1.0 ft >30 days	1-in-4
WCA-2B	2B-21	23	Peat	-1.0 ft >30 days	1-in-3[c]
WCA-3A North	3A-NE	21	Peat	-1.0 ft >30 days	1-in-2
WCA-3A North	3A-NW	22	Peat	-1.0 ft >30 days	1-in-4
WCA-3A North	3A-2	20	Peat	-1.0 ft >30 days	1-in-4
WCA-3A North	3A-3	68	Peat	-1.0 ft >30 days	1-in-3
WCA-3A central	3A-4	17	Peat	-1.0 ft >30 days	1-in-4
WCA-3A South	3A-28	14	Peat	-1.0 ft >30 days	1-in-4
WCA-3B	3B-SE	16	Peat	-1.0 ft >30 days	1-in-7
Everglades Agricultural Area					
Rotenberger WMA	Rotts	28	Peat	-1.0 ft >30 days	1-in-2
Holey Land WMA	HoleyG	29	Peat	-1.0 ft >30 days	1-in-3
Everglades National Park					
NE Shark River Slough	NESRS-2	11	Peat	-1.0 ft >30 days	1-in-10
Central Shark River Slough	NP-33	10	Peat	-1.0 ft >30 days	1-in-10
Central Shark River Slough	NP 36	9	Peat	-1.0 ft >30 days	1-in-7
Marl wetlands east of Shark River Slough	NP-38	70	Marl	-1.5 ft >90 days	1-in-3[d]
Marl wetlands west of Shark River Slough	NP-201 G-620	12	Marl	-1.5 ft >90 days	1-in-5
Rockland marl marsh	G-1502	8	Marl	-1.5 ft >90 days	1-in-2[d]
Taylor Slough	NP-67	1	Marl	-1.5 ft >90 days	1-in-2[d]

a. Indicator regions are groupings of model grid cells within the SFWMM consisting of similar vegetation cover and soil type. These larger grouping of cells were developed to reduce the uncertainty of evaluating results from a single two by two, square mile grid cell that represents a single water management gage. **Figure 38** provides the location of each indicator region.

b. Return frequencies for peat based wetlands located within the WCAs were based largely on output of the NSMv4.5F.

c. Expert opinion of District staff and results from the NSM concur that a 1-in-6 return frequency is needed to protect peat soils of this region from significant harm. District staff recognizes that this value had to be modified to account for consideration of changes and structural alterations that have occurred to the hydrology of WCA-2B. Model results of the CERP and LEC water supply planning process suggest full restoration of WCA-2B may not be possible. A policy decision was made to present a MFL return frequency of 1-in-3 in this table to reflect conditions that can be practically achieved.

d. These return frequencies reflect the expert opinion of District staff based on agreed upon management targets developed in the CERP and LEC planning processes and output of the NSM. It is the expert opinion of Everglades National Park staff that NSM does not properly simulate hydrologic conditions within the Rockland marl marsh and Taylor Slough, and the proposed return frequencies listed above may not necessarily protect these marl-forming wetlands from significant harm. They propose that a frequency of 1-in-5 may be necessary to prevent significant harm from occurring to these unique areas of Everglades National Park.

Table 41. Minimum Flows and Levels Results in the Base Case and Alternative Simulations for the Everglades.[a]

Geographic Location				Return Frequency (Years)				
Area	**Gage**	**IR[b]**	**Soil**	**Target**	**1995 Base Case**	**2020 Base Case**	**2020 With Restudy**	**LEC-1**
Water Conservation Areas								
WCA-1	1-7	27	peat[c]	1-in-4	1-in-15	1-in-4	1-in-10	1-in-15
WCA-2A	2A-17	24	peat	1-in-4	1-in-4	1-in-4	1-in-3	1-in-3
WCA-2B south	2B-21	23	peat	1-in-3	1-in-3	1-in-4	1-in-3	1-in-3
WCA-3A north	3A-NE	21	peat	1-in-2	1-in-1.6	1-in-4	1-in-2	1-in-2
WCA-3A north	3A-NW	22	peat	1-in-4	1-in-1.5	1-in-3	1-in-4	1-in-6
WCA-3A north	3A-2	20	peat	1-in-4	1-in-2	1-in-3	1-in-4	1-in-4
WCA-3A north	3A-3	68	peat	1-in-3	1-in-5	1-in-3	1-in-3	1-in-3
WCA-3A central	3A-4	17	peat	1-in-4	1-in-5	1-in-3	1-in-8	1-in-8
WCA-3A South	3A-28	14	peat	1-in-4	PF	1-in-4	1-in-6	1-in-8
WCA-3B	3B-SE	16	peat	1-in-7	1-in-3	1-in-2	1-in-10	1-in-10
Everglades Agricultural Area								
Holey Land	HoleyG	29	peat	1-in-3	1-in-5	1-in-6	1-in-3	1-in-3
Rotenberger	Rotts	28	peat	1-in-2	1-in-1	1-in-1	1-in-2	1-in-2
Everglades National Park								
NE Shark Slough	NESRS-2	11	peat	1-in-10	1-in-3	1-in-3	1-in-15	1-in-15
Central Shark Slough	NP-33	10	peat	1-in-10	1-in-3	1-in-4	1-in-15	1-in-15
SW Shark Slough	NP-36	9	peat	1-in-7	1-in-3	1-in-4	1-in-8	1-in-8
NW Shark Slough	NP-201/ G-620	12	marl[d]	1-in-5	1-in-3	1-in-3	1-in-6	1-in-6
Rockland Marl	G-1502	8	marl	1-in-2	1-in- 1	1-in-1.3	1-in-1.3*	1-in-1.5*
Marl wetland east Shark River Slough	NP-38	70	marl	1-in-3	1-in-1.2	1-in-2	1-in-2	1-in-3
Taylor Slough	NP-67	1	marl	1-in-2	1-in-2	1-in-2	1-in-2	1-in-2
Total Violations (number of sites which do not meet criteria					12/19	12/19	3/19	2/19

a. [white box] = exceeds proposed MFL criteria; [shaded box] = meets proposed MFL criteria

b. IR = Indicator Region

c. MFL criterion for peat-forming wetlands are –1.0 ft. below ground >30 days

d. MFL criterion for marl-forming wetlands are – 1.5 ft. below ground >90 days northern Everglades as part of the C&SF Project. During dry periods these canals lower ground water levels and over drain these wetlands causing extensive peat fires, soil subsidence, changes in Everglades vegetation communities, and impacts to wildlife species. MFLs were not met in northern WCA-3A, WCA-3B, and within the Rotenberger WMA. In Everglades National Park, MFLs were not met within northeastern and central Shark River Slough, the Rockland marl marsh, and marl wetlands located east and west of Shark River Slough. Areas that did meet the proposed criteria included the Loxahatchee National Wildlife Refuge (WCA-1); WCA-2A, WCA-2B; eastern, central and southern WCA-3A; the Holey Land WMA; and Taylor Slough located within Everglades National Park (**Table 41**).

2020 Base Case. The ability of the regional system to meet MFLs did not improve under the 2020 Base Case, where again only 12 of 19 monitoring sites exceeded the proposed criteria (**Table 41**). However, northeast WCA-3A showed improvement in response to hydroperiod improvements associated with completion of STA-3 and STA-4 and the reestablishment of sheetflow to northeast WCA-3A.

LEC 2020 with Restudy and LEC-1. Implementation of the LEC 2020 with Restudy and LEC-1 alternatives significantly improved the system's ability to meet the proposed MFL criteria. Under the LEC 2020 with Restudy alternative, 17 of 19 sites met the proposed criteria (**Table 41**). MFL performance was slightly improved under LEC-1, with 18 of 19 Indictor Regions meeting the proposed criteria. Areas that showed the most improvement were northern, central, and southern WCA-3A; WCA-3B; Holey Land and Rotenberger WMAs; northeast and central Shark River Slough; marl wetlands west of Shark River Slough (Indicator Region 12); and Taylor Slough within Everglades National Park. Areas that still need improvement included WCA-2A, the Rockland marl marsh (Indicator Region 8), and NP-38 (Indictor Region 70) located within Everglades National Park (**Table 41**).

Incremental Results

1995 Revised Base Case. Model simulations show that under the 1995 Revised Base Case, proposed minimum water level criteria are not met for 11 out of 19 indictor regions located within the northern Everglades and Everglades National Park (**Table 42**). MFLs were not met in WCA-2A, portions of northern WCA-3A (Indicator Regions 20, and 22), WCA-3B, the Rotenberger WMA, Shark River Slough, the Rockland marl marsh, and marl wetlands located east and west of Shark River Slough. Areas that met the proposed criteria are the Loxahatchee National Wildlife Refuge (WCA-1), WCA-2B, portions of northern WCA-3A (Indicator Regions 21 and 68), central and south WCA-3A, Holey Land WMA, and Taylor Slough.

2010, 2015, and 2020. Conditions did not begin to improve in the northern Everglades until 2010, and improvements continued incrementally through 2020 when all areas meet MFL criteria. In Everglades National Park, performance did not improve until 2020, mostly because components of the Lake Belt Project could not to be implemented until 2020. By 2020, proposed MFL criteria are met at 17 of the 19 sites.

Table 42. Minimum Flows and Levels Results of the 2005 Incremental Simulation and the 2005 SSM Scenario for the Everglades.[a]

Geographic Location				Return Frequency (Years)			
Area	Gage	IR[b]	Soil	Target	1995 Revised	2005	2005 SSM Scenario
Water Conservation Areas							
WCA-1	1-7	27	peat[c]	1-in-4	1-in-15	1-in-6	1-in-6
WCA-2A	2A-17	24	peat	1-in-4	1-in-3	1-in-2	1-in-2
WCA-2B south	2B-21	23	peat	1-in-3	1-in-3	1-in-2	1-in-2
WCA-3A north	3A-NE	21	peat	1-in-2	1-in-1.6	1-in-3	1-in-3
WCA-3A north	3A-NW	22	peat	1-in-4	1-in-1	1-in-2	1-in-2
WCA-3A north	3A-2	20	peat	1-in-4	1-in-2	1-in-2	1-in-2
WCA-3A north	3A-3	68	peat	1-in-3	1-in-5	1-in-4	1-in-4
WCA-3A central	3A-4	17	peat	1-in-4	1-in-5	1-in-4	1-in-4
WCA-3A South	3A-28	14	peat	1-in-4	PF[d]	1-in-31	1-in-31
WCA-3B	3B-SE	16	peat	1-in-7	1-in-3	1-in-3	1-in-3
Everglades Agricultural Area							
Holey Land	HoleyG	29	peat	1-in-3	1-in-5	1-in-6	1-in-8
Rotenberger	Rotts	28	peat	1-in-2	1-in-1	1-in-1	1-in-1
Everglades National Park							
NE Shark Slough	NESRS-2	11	peat	1-in-10	1-in-3	1-in-3	1-in-3
Central Shark Slough	NP-33	10	peat	1-in-10	1-in-3	1-in-3	1-in-3
SW Shark Slough	NP-36	9	peat	1-in-7	1-in-3	1-in-3	1-in-3
NW Shark Slough	NP-201/ G-620	12	marl[e]	1-in-5	1-in- 3	1-in-3	1-in-3
Rockland Marl	G-1502	8	marl	1-in-2	1-in- 1	1-in-1.5	1-in-1.5
Marl wetland east Shark River Slough	NP-38	70	marl	1-in-3	1-in-1	1-in-2	1-in-2
Taylor Slough	NP-67	1	marl	1-in-2	1-in-2	1-in-2	1-in-2
Total Violations (number of sites which do not meet criteria					12/19	12/19	12/19

a. [white box] = exceeds proposed MFL criteria; [shaded box] = meets proposed MFL criteria

b. IR= Indicator Region

c. MFL Criteria for peat-forming wetlands are –1.0 ft. below ground >30 days

d. Permanently flooded

e. MFL criterion for marl-forming wetlands are – 1.5 ft. below ground >90 days

2005 and 2005 SSM Scenario. Review of MFL performance for the Everglades showed no major differences between the 2005 incremental simulation and the 2005 SSM Scenario results (**Table 42**). After review of stage hydrographs, stage duration curves, inundation summary tables, and high and low water criteria (Appendix H) it was concluded that there was insignificant, if any, difference between the 2005 incremental simulation and the 2005 SSM Scenario. All performance measures for the Everglades showed virtually identical behavior of the system under both.

Biscayne Bay

Performance Measures Applied

For purposes of this study, the performance measure for Biscayne Bay is that future flows delivered to the estuary should not be less than those currently discharged to the bay under the 1995 Base Case. Mean annual wet and dry season flows were based on SFWMM output for the primary water management structures which discharge into the northern, central, and southern portions of Biscayne Bay. These structures included the following:

- Northern Biscayne Bay: Snake Creek (2-29), G-58, S-28, and S-27
- Central Biscayne Bay: Miami River (S-25, S-25B, and S-26), G-97, S-22, and S-123
- Southern Biscayne Bay: S-21, S-21A, S-20F, and S-206

Base Cases and Alternatives Results

1995 and 2020 Base Cases. Overall increased regional water demands in 2020 reduced the total amount of water discharged to Biscayne Bay by approximately 12 percent as compared to the 1995 Base Case (**Table 43**). Flows were reduced by four percent for the northern bay, 23 percent for the central bay, and three percent for the southern portion of Biscayne Bay under the 2020 Base Case.

LEC 2020 with Restudy and LEC-1. Performance of the 2020 with Restudy and LEC-1 alternatives showed total mean annual surface flows delivered to the bay to be reduced by 24 and 30 percent as compared to the 1995 Base Case (**Table 43**). These reductions in flow were caused primarily by construction of the C-4 structures which reduced the amount of water discharged through S-25B and the Miami Canal which drains into central Biscayne Bay. As a result, the largest reduction in flow occurred within central Biscayne Bay under the 2020 with Restudy and LEC-1 alternatives (**Table 43**).

In contrast, flows delivered to south Biscayne Bay increased by 11 and 20 percent for the 2020 with Restudy and LEC-1 alternatives, respectively, as compared to the 1995 Base Case. This increase in water flow to southern Biscayne Bay was the result of incorporation of the water reuse component contained within both the 2020 with Restudy and LEC-1 alternatives (**Table 43**).

Table 43. Total Mean Annual Flows Discharged into Northern, Central, and Southern Biscayne Bay for the Base Case and Alternatives during the 31-Year Simulation Period.

	Average Annual Flow (acre-feet x 1,000)			
	1995 Base Case[a]	2020 Base Case	2020 with Restudy	LEC-1
North Bay	312	298	241	145
Central Bay	434	335	252	269
South Bay	223	215	247	267
Totals	969	848	740	681
Percent increase (+) or reduction (-)	NA	- 12%	- 24%	- 30%

a. Target

Incremental Results

The 2005 and LEC-1 Revised incremental simulations also report significant reductions in mean annual flows delivered to the bay as a whole compared to the 1995 Base Case. The reductions were 21 and 18 percent for 2005 incremental simulation and LEC-1 Revised, respectively (**Table 44**). These results, however, vary from basin to basin. In north Biscayne Bay, mean average annual flows remain near 1995 Base Case values in 2005, and actually increase in 2010 and 2015 and then decrease in 2020 due to inclusion of the Lake Belt Projects.

Table 44. Total Mean Annual Flows Discharged into Northern, Central, and Southern Biscayne Bay for the Incremental Simulations during the 31-Year Simulation Period.

	Average Annual Flow (acre-feet x 1,000)					
Area	Target	1995 Revised Base	2005	2010	2015	LEC-1 Revised
North Bay	300*	317	300	347	340	259
Central Bay	452	430	263	341	417	263
South Bay	226	222	203	219	217	268
Totals	978	969	766	907	974	790
Percent increase (+) or reduction (-)		+ 1%	-22%	-7%	-0.4%	-19%

The most striking results occur in central Biscayne Bay in 2005 where total flows delivered to the bay drop by more than 60 percent compared to 1995 Base Case (**Table 44**). This is due to construction of the C-4 structures, which significantly reduce flows from S-25B, which discharge into the Miami Canal and central Biscayne Bay. These values increase in 2010 and 2015, but decrease again in 2020, in part due to the Lake Belt Project coming on line.

In contrast, there are noticeable improvements in southern Biscayne Bay where water reuse projects increase flows to the south by about 20 percent by 2020. These improved flows should improve estuarine conditions in this area of the bay by 2020.

Biscayne Aquifer Minimum Flows and Levels

Base Cases and Alternatives Results

All of the base cases and alternatives show the ability to meet the proposed minimum canal operational levels for the Biscayne aquifer MFL for the 31-year simulation period (**Table 45)**. These results indicate that the Biscayne aquifer is not threatened by saltwater intrusion in any of these simulations due to the inability to maintain coastal canals.

Table 45. The number of Times Minimal Minimum Flows and Levels Operational Criteria was not Met for the Biscayne Aquifer.

Canal/Structure	Minimum Canal Operation Levels to Protect Against MFL Violations[a]	1995 Base Case	2020 Base Case	2020 with Restudy	LEC-1
C-51/S-155	7.80	0	0	0	0
C-16/S-41	7.80	0	0	0	0
C-51/S-40	7.80	0	0	0	0
Hillsboro/G-56	6.75	0	0	0	0
C-14/S-37B	6.50	0	0	0	0
C-13/S-36	4.00	0	0	0	0
N.N. River/G-54	3.50	0	0	0	0
C-9/S-29	2.00	0	0	0	0
C-6/S-26	2.00	0	0	0	0
C-4/S-25B	2.20	0	0	0	0
C-2/S-22	2.20	0	0	0	0

a. Duration criteria: Water levels within the above canals may fall below the proposed minimum operational level for a period of no more than 180 days per year.

Summary of Minimum Flows and Levels

Lake Okeechobee

MFLs were met in Lake Okeechobee for the 1995 and 2020 Base Cases, the 2020 with Restudy, and the LEC-1 alternatives, as well as the 2005 through 2020 incremental simulations. As a result, exceedences of the MFL criteria are not expected to occur even if the LEC Regional Water Supply Plan is not implemented. Therefore, neither a MFL recovery plan nor a prevention strategy is required for Lake Okeechobee.

The Everglades

In contrast, MFL criteria are not met for 12 of 19 selected monitoring sites located within the Everglades (i.e., the WCAs, Everglades National Park, and the Rotenberger and Holey Land WMAs) for both the 1995 and 2020 Base Cases. These results indicate that a MFL recovery plan will be needed for these areas.

Analysis of the 2020 with Restudy and LEC-1 show major improvements in meeting the proposed MFL criteria by 2020. Incremental modeling results show improvements in meeting MFLs within the northern Everglades by 2010 and 2015 as a result of construction of the Everglades Construction Project and the EAA reservoir. MFLs are met for the majority of sites located within Everglades National Park by 2020 as a result of construction and operation of 50 percent of the Lake Belt projects. By 2020 only two Everglades monitoring sites out 19 do not meet the proposed MFL criteria.

Biscayne Aquifer

All of the base cases and alternatives met the proposed minimum canal operational levels for the Biscayne aquifer for the 31-year simulation period. These results indicate that the Biscayne aquifer is not threatened by saltwater intrusion in any one of these simulations due to the inability to maintain coastal canals levels. As a result, the proposed minimum canal operational levels are not expected to be exceeded even if the LEC Regional Water Supply Plan is not implemented. Therefore, neither a MFL recovery plan nor a prevention strategy is required for the Biscayne aquifer at this time.

Summary of Results for Natural Areas

Results of the modeling show that over time the following occur:

Lake Okeechobee. Implementation of the WSE schedule in Lake Okeechobee results in a number of hydrologic improvements that should benefit the overall ecology of the ecosystem. These improvements begin in 2005, with LEC planning targets being met by 2015.

St. Lucie and Caloosahatchee Estuaries. Construction of regional reservoirs combined with water management improvements in Lake Okeechobee by 2010 result in significant reductions in the number of high volume discharge events that impact both the St. Lucie and Caloosahatchee estuaries. These hydrologic improvements should help to provide a salinity regime that will provide significant ecological benefits to both ecosystems.

Lake Worth Lagoon. Construction of STA-1E and other improvements to the regional system result in a significant reduction in the number of high volume discharges events that impact the Lake Worth Lagoon.

Holey Land and Rotenberger Wildlife Management Areas. In the EAA, completion of the Everglades Construction Project (ECP) and EAA reservoir, and implementation of rainfall-driven water delivery schedules for the Holey Land and Rotenberger Wildlife Management Areas provide significant ecological benefits to these over drained areas by 2010.

WCA-3A and 3B: Likewise, completion of the Everglades Construction Project, construction of the EAA reservoirs, and implementation of rainfall-driven water delivery schedules within northern WCA-3A reintroduces sheetflow to the northern Everglades system and meets NSM-defined hydrologic targets in northern WCA-3A by 2010. These improvements should provide significant ecological benefits to this historically over drained area of the Everglades system. In addition, WCA-3B and southern WCA-3A show gradual improvements over time and come close to meeting NSM-defined targets by 2020.

Everglades National Park. Modeling results show a gradual improvements over time in providing increased flows delivered to Everglades National Park. Beginning in 2005 there is a significant improvement in both the distribution and volume of water delivered to northeast and northwest Shark River Slough. By 2010 significant improvements in meeting NSM hydroperiod targets were recorded within northeast and central Shark River Slough, with near full recovery by 2020 (100 percent of the slough matches the NSM hydroperiod target by 2020). In the Rockland marl marsh, significant hydroperiod improvements were noted beginning in 2005 within this over drained area. These improvements continue through 2020.

Florida Bay. Results also show major improvements over time in providing increased flows delivered toward western Florida and Whitewater bays. These increased flows should provide significant ecological benefits to an area that has been subject to reduced flows as a result of construction of the C&SF Project.